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16. ABSTRACT

Fifty-two bottom sediment box core samples were taken in fall 1978 and summer 1979 to investigate the relationship between benthic biota and the sedimentary environment of the upper and central Chesapeake Bay. Examination of the vertical distribution of the benthos and radiographic analysis of the sediments determined the degree of physical and biological activities and interactions.

The benthic macrofauna were characterized by opportunistic as well as equilibristic species that inhabit a wide range of salinity and substrate types. The number of species increased down the estuary. Greatest species populations were found in the mixed-sediment type environments. The benthos were concentrated in the top 10 cm of the sediment with penetration to 30 cm or more. Most sedimentary environments have a deep-dwelling faunal component, with the number of deep-penetrating individuals being greatest in the mixed-sediment environments. All taxa had deep-dwelling representatives except for the arthropods. Many of the deep-dwelling species were also considered dominants based on numerical as well as biomass determinations.

Biological sediment mixing (bioturbation) occurs in most areas of Chesapeake Bay. The degree of bioturbation is substantially reduced in the upper region of the Bay because of high sedimentation rates. The prevalence of physical structures over biological features in the deep-water channel regime is due to the presence of fluid muds and periodic anoxia. The more stable mud environment is primarily inhabited by a sedentary tube and relatively permanent burrow-building community. Sands are characterized by a motile fauna. Most biogenic structures are produced by polychaetous annelids. Species population patterns and previous Pb^{210} data in Chesapeake Bay suggest that biological mixing occurs down to 30 cm, being greatest at the sediment surface.

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Animal-Sediment Relationships of the Upper and Central Chesapeake Bay

by

Eli Reinharz and Arthur E. O'Connell

ABSTRACT

Fifty-two box core samples were taken in fall, 1978 and summer, 1979 in order to acquire a better understanding of the biota of the upper and central Chesapeake Bay in relationship to the sedimentary environment. Investigation of the vertical distribution of the benthos and radiographic examination of the sediments highlights the degree to which physical and biological conditions prevail.

The macrofauna were characterized by opportunistic as well as equilibristic species inhabiting a wide range of salinity and substrate types. The number of species increased down the estuary. Greatest species populations (number of species and individuals) were found in the mixed-sediment environments. The benthos were concentrated in the top 10 cm of the sediment with penetration to 30 cm or more. Most sedimentary environments have a deep-dwelling faunal component, the number of deep-penetrating individuals being greatest in the mixed-sediment environments. All taxa had deep-dwelling representatives except for the arthropods. Many of the deep-dwelling species were also considered dominants based on numerical as well as biomass determinations.

Biological activities predominate in most areas of the Chesapeake estuary. The degree of bioturbation is substantially reduced in the upper region of the Bay because of active sedimentation. The prevalence of physical structures over biological features in the deep-water channel regime is due to the presence of fluid muds and periodic anoxia. The more stable mud environment is primarily inhabited by a sedentary tube and relatively permanent burrow-building community. Sands are characterized by a motile fauna. Most biogenic structures are produced by polychaetous annelids. Species population patterns and previous Pb^{210} data in the Chesapeake Bay suggest that biological mixing occurs down to 30 cm, being greatest at the sediment surface.

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INTRODUCTION

The accumulation of toxic materials (biocides, metals and radionuclides) in the Chesapeake Bay is a significant problem area. Toxicants are continually being introduced into this productive system. They adsorb onto particulate matter which eventually settles in bottom sediments. These sediment-borne toxicants may remain in the estuarine basin, potentially being remobilized and deleteriously affecting various components of the food chain. Unfortunately, not enough is known concerning the distribution of toxicants in the Bay and the geophysical processes that may determine their distribution. The paucity of information is even more overwhelming when considering biological processes which may influence the fate of toxic substances.

Appreciation of the benthic community structure is vital to our understanding of animal-sediment-toxicant relationships. Previous research concerning the benthic environment has followed three different avenues. For nearly a century, researchers have described physical and biogenic sedimentary structures in order to explain past environmental conditions (see reviews of Frey, 1973; Reineck and Singh, 1975). More recent scientific endeavors have focused on the contemporary nature of the sedimentary environment, examining factors which control benthic dispersion patterns on the one hand (Sanders, et al., 1963; Gray, 1974; McCall, 1977) and the effects of bottom-dwelling organisms on the other (Winston and Anderson, 1971; Davis, 1974 a&b; Rhoads, 1974; Guinasso and Schink, 1975; Howard and Frey, 1975; Aller, 1977; Robbins, et al., 1979). Prior research demonstrates that benthic organisms have a considerable influence on the stratigraphy as well as physical and chemical properties of the sediment in areas where physical processes do not predominate.

The surficial distribution of benthic organisms in the Chesapeake Bay is well documented (Boesch, 1977; Holland, et al., 1977; Mountford, et al., 1977; Loi and Wilson, 1979). The biota are primarily controlled by substrate type and salinity variation. Despite the rather thorough knowledge of benthic patterns, we have a poor understanding concerning the biota vis á vis the sedimentary and geochemical milieu. To help bridge this gap, biological research under the auspices of the Toxics Substances Program, Environmental Protection Agency-Chesapeake Bay Program has investigated the vertical distribution of the benthos and sedimentary structures. This information was obtained by utilizing a box core sampler and X-radiographic techniques, respectively. Such aspects qualitatively highlight the degree to which physical and biological activities influence the fate of toxic materials. The Chesapeake Bay Earth Science Study of the Maryland Geological Survey and the Virginia Institute of Marine Science have worked in conjunction with other sedimentological and geochemical studies which have addressed the problem of the distribution of toxicants in the Chesapeake estuarine system.

METHODS

A total of 52 box core samples were taken in the upper (oligohaline zone) and central (mesohaline zone) Chesapeake Bay (Figure 1). Twenty-five sites were examined between September and November of 1978, and twenty-seven areas were sampled during June and July of 1979, revisiting 12 stations of the previous season. We conducted biological sampling in conjunction with coring for sedimentology and interstitial water chemistry.

We utilized a modified United States Navy Electronics Laboratory (U.S.N.E.L.) spade box corer. This sampler extracts a sediment surface of 0.063 m^2 with a maximum penetration of 60 cm. The corer provides a quantifiable volume of sediment and maintains the sample in a relatively undisturbed manner (Bouma and Marshall, 1964).

Our strategy was to recover two box cores per station; one for determination of the vertical distribution of the benthic community and the other for X-radiographic analysis, dissection and visual observations. The surface topography and vertical profiles of each core were recorded and photographed (color and/or black and white). The information derived from both cores was synthesized to produce a three-dimensional schematic diagram of the sedimentary enviornment for each station and its biotic community.

1. Abiotic Environment

Sediment aliquots were extracted along the vertical axis of each core consistent with benthic sectioning (refer to section 2). Additional subsectioning of the radiograph slabs (see section 3) further served to identify and verify similar sediment patterns between the two companion cores. Physical sediment characteristics were analyzed using the procedure of Folk, 1974. Determination of the silt and clay fraction was made via pipette analysis and measured with the Coulter Counter. Sand content was ascertained with the Rapid Sediment Analyzer (RSA) settling tube.

Bottom salinity and temperature were measured at each station. Salinity, temperature and dissolved oxygen determinations have been previously made for the Bay area, showing seasonal and annual trends (Hires, et al., 1963; Stroup and Lynn, 1963; Taft, et al., 1980).

2. Benthic Distribution Patterns

One box core was used for the quantification of the benthic community. Increments were established at 0-5, 5-10, 10-20, 20-30, 30-40 cm, etc. for the fall samples to determine vertical population trends. For a slightly more accurate assessment of animal distribution patterns, these intervals

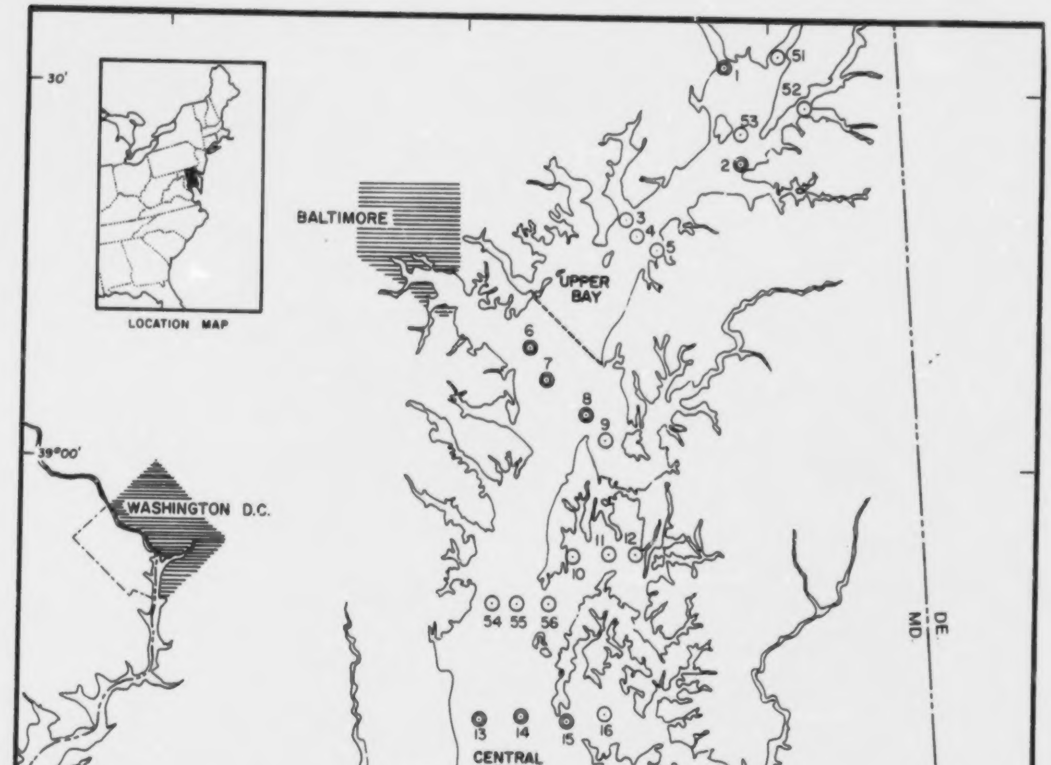
LOCATION MAP
BALTIMORE
UPPER BAY
WASHINGTON D.C.
CENTRAL BAY
MD.
VA.
DE.
MD.
30'
39°00'
30'
38°00'
77°00'
30'
76°00'
10
0
10 miles
1
2
3
4
5
6
7
8
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Figure 1: Sampling sections in the upper and central Chesapeake Bay. (◉ seasonal sites)

were reduced during the summer cruise as follows: 0-2, 2-5, 5-10, 10-15, 15-20, 20-30, 30-40 cm, etc. The entire sample, except for a sediment subsample, from each interval was examined for species counts. All biological samples were sieved through a 0.5 mm mesh screen on board ship to collect the macrobenthos. Organisms were fixed in 10% formalin and preserved a few days later in 70% ethanol. After species identification and enumeration, benthic organisms were oven dried at 65°C until constant weight was obtained for biomass determinations. Mollusc shells were dissolved in 10% HCl and polychaetes were removed from their tubes so that biomass comparisons could be made between taxa.

3. Bioturbation and Sedimentary Structures

Techniques for radiographic processing are outlined in Howard and Frey, 1975. Upon dismantling one side of the remaining box core, a 6 cm vertical slice was sectioned and sealed in a plexiglass tray for subsequent laboratory procedures. The samples were refrigerated at 4°C to preserve the intrinsic qualitites of the substrate. Core sections were trimmed to a thickness of 2 cm; the optimum depth required for a clean and detailed picture of the sediment core. The remainder of the sample was dissected to determine the placement and penetration of the benthos.

Radiographs were taken with a Torr 120 kv medical X-ray unit. Amperage and focal distance were maintained at a constant 3 ma and 95 cm, respectively. The voltage and exposure times ranged between 50-60 kv and 60-150 sec. Kodak AA-5 Industrial X-ray film produced fine grain, high contrast images (Bouma, 1969).

RESULTS

1. Abiotic Environment

Salinity and temperature values in the Chesapeake Bay waters follow a similar pattern to that of other temperate estuaries. Greatest variations of these physical parameters occur in the spring, smallest in the fall. The water column tends to become stratified during the summer. In the upper and central Bay region, annual salinities range from 0-21% and temperatures vary from 1-30°C. Salinities characteristically increase with water depth. We have recorded the following bottom salinity and temperature ranges during the course of this study: fall (1.5-21%o, 15.3-23.8°C); summer (0.2-17.9%o, 20.1-24.8°C). Low dissolved oxygen (<3 ml/l) or anoxic conditions often develop during the summer months.

Substrate characteristics generally vary with water depth (Ryan, 1953; Palmer, 1975). It should be noted, however, that there are some areas of patchiness where this trend is not present. Sediments vary from coarse sands in the upper section of the Bay and along the shore flanks to clays in the channel regime. Most of the estuarine basin (>80%) consists of mud.

The sediments in this investigation have been classified on the basis of the relative weight percentage of mud (≤62μm) and specific biotic indicators: (a) sands (<15% mud), (b) mixed sediments (10-85% mud) and (c) muds (>90% mud). Mixed sediments are comprised of muddy sands and sandy muds; the delineation between these subdivisions being the 50% mud mark.

Appendix I details the vertical grain size distribution (percent sand, silt and clay) throughout the length of each core. Several trends are evident. Sediment distribution remains constant in relationship to depth at most stations (≈45% of the stations). In a number of other cores (≈35% of the stations), some gradation occurs; this is usually found as an increase of the silt or clay fractions with depth. Random textural variations were also present in several areas (≈17% of the stations), but were most often found in the upper Bay. Stations exhibiting sediment textural changes reflect the temporal variability of the environment.

2. Benthic Distribution Patterns

Sampling stations have been divided into major habitat types based on substrate characterization and salinity regime (Table 1). Since data for cores extracted from the meso-polyhaline zone (lower Bay) is covered in the Virginia Institute of Marine Science final report, only the oligohaline (upper Bay) and mesohaline (central Bay) regimes are considered in this section. Therefore, 40 cores (8 sites revisited) have been analyzed regarding the distribution of the benthic community.

Table 1: Stations sampled in major habitat types.

Fall 1978

Salinity Regime	Substrate Type		
	Mud	Mixed Sediment	Sand
Oligohaline	3, 4, 5	2	1
Mesohaline	6, 7, 8, 9, 10, 13, 14, 18, 19	15, 16, 17	11, 12
*Meso-polyhaline transition	23, 24	22	20, 21, 25

Summer 1979

	Mud	Mixed Sediment	Sand
Oligohaline	-	2, 52, 53	1, 51
Mesohaline	6, 8, 13, 14, 54, 55, 57, 58, 60, 62, 64	7, 15, 56, 61, 63	59
*Meso-polyhaline transition	23, 25	21	25, 65

*Meso-polyhaline transition stations are included in Virginia Institute of Marine Science final report.

Faunal Composition

We have collected a total of 5665 individuals belonging to 38 species. Annelids were the most numerous group (2945 individuals) with arthropods second (2048 individuals) and molluscs third (591 individuals). Arthropods, represented by 14 species, were the most diverse group whereas annelid and mollusc populations consisted of 12 and 10 species respectively. The dominant taxonomic classes within each of the above categories are polychaetes with 2205 individuals and 11 species, crustaceans with 1936 individuals and 9 species, and bivalve molluscs with 589 individuals and 8 species. Miscellaneous groups, such as the nemerteans, were represented by 81 individuals and 2 species. Appendix II and III list the macrobenthic species collected in the upper and central Chesapeake Bay, and at each station.

Species distributions are summarized in Table 2. Comparisons of habitats between seasons shows an increase in the total number of species from fall to summer. This pattern may be the result of sampling different stations during the two seasons rather than new recruitment potential. Mean species numbers reveal that the mixed-sediment environments contain the largest species assemblage. Both the total and mean number of species values indicate that arthropods and annelids, namely polychaetes, are the principal taxonomic components in the oligohaline and mesohaline regimes, respectively.

Data on the mean number of individuals show more discrepant patterns from that of species trends (Table 3). The density of individuals is greater in the mixed-sediment environments. In the oligohaline regime, higher densities occur in the fall than in the summer. This increase can be attributed to the greatest abundance of oligochaetous annelids during the fall and their subsequent decline in the summer. Most other species densities tend to increase during the summer due to spring recruitment efforts. This pattern of increase is also evident in the mesohaline regime. Oligochaetous annelids and arthropods are co-dominant groups in the oligohaline zone based on the number of individuals whereas polychaetous annelids are the principal groups in the mesohaline regime.

Like numerical abundance patterns, a great deal of seasonal variation in biomass is apparent when examining the different habitat types (Table 4). Much of this seasonal change is related to the weight values of a few species. Overall biomass, however, was slightly higher during the summer and was greatest in the mixed-sediment environments. Annelids in the oligohaline zone and molluscs in the mesohaline regime have the greatest biomass.

The variability that exists between number of individuals and species, and biomass tends to be reflected in shifts of dominant species (Tables 5 and 6). McCloskey's Biological Index (1970) was used to rank species based on their abundance (or biomass) as well as frequency of occurrence.

Table 2: Total (T) and mean (M) number of species in major habitat types.

Oligohaline Regime

	Fall 1978					Summer 1979				
	Annelids	Arthropods	Molluscs	Other	Total	Annelids	Arthropods	Molluscs	Other	Total
T Mud(M)	2 (1.7)	4 (3.0)	1 (0.7)	1 (0.3)	8 (5.7)	- (-)	- (-)	- (-)	- (-)	- (-)
Mixed T Sediment(M)	2 (2.0)	4 (4.0)	2 (2.0)	- (-)	8 (8.0)	3 (2.3)	7 (3.0)	2 (0.7)	1 (0.3)	13 (6.3)
T Sand (M)	1 (1.0)	2 (2.0)	1 (1.0)	- (-)	4 (4.0)	2 (1.5)	3 (2.5)	- (-)	- (-)	5 (4.0)
T *Overall(M)	2 (1.5)	5 (3.0)	3 (1.5)	- (-)	10 (6.0)	3 (1.8)	8 (2.8)	2 (0.4)	1 (0.2)	14 (5.2)

Mesohaline Regime

	Fall 1978					Summer 1979				
	Annelids	Arthropods	Molluscs	Other	Total	Annelids	Arthropods	Molluscs	Other	Total
T Mud(M)	6 (3.4)	4 (0.9)	2 (1.0)	1 (0.2)	13 (5.5)	10 (3.8)	5 (0.9)	5 (1.8)	1 (0.5)	21 (7.0)
Mixed T Sediment(M)	9 (7.0)	2 (1.3)	2 (2.0)	1 (0.3)	14 (10.6)	10 (5.2)	4 (1.6)	3 (2.4)	2 (1.0)	19 (10.2)
T Sand(M)	4 (3.5)	- (-)	2 (1.5)	1 (1.0)	7 (6.0)	6 (6.0)	2 (2.0)	6 (6.0)	2 (2.0)	14 (14.0)
T Overall(M)	8 (4.2)	4 (0.9)	2 (1.3)	1 (0.4)	15 (6.8)	12 (4.4)	8 (1.2)	7 (2.2)	2 (0.8)	29 (8.8)

* Oligohaline mud habitat is not included in the calculations.

Table 3: Mean number of individuals in major habitat types.

Oligohaline Regime

	Fall 1978					Summer 1979				
	Annelids	Arthropods	Molluscs	Other	Total	Annelids	Arthropods	Molluscs	Other	Total
Mud	18.0	102.3	0.7	0.3	121.3	-	-	-	-	-
Mixed Sediment	192.0	19.0	3.0	-	214.0	72.6	12.3	1.0	0.7	86.6
Sand	100.0	13.0	2.0	-	115.0	9.0	21.5	-	-	30.5
*Overall	146.0	16.0	2.5	-	164.5	47.1	14.4	0.6	0.4	62.5

Mesohaline Regime

	Fall 1978					Summer 1979				
	Annelids	Arthropods	Molluscs	Other	Total	Annelids	Arthropods	Molluscs	Other	Total
Mud	46.3	14.2	5.1	0.9	66.5	77.7	72.6	22.4	1.4	174.1
Mixed Sediment	80.3	102.3	35.7	0.3	218.6	146	78.8	29.8	4.4	259.0
Sand	30	-	6.5	3.5	40	47	11	14	22	94.0
Overall	51.3	31.1	11.9	1.1	95.4	96.0	70.8	24.1	3.5	194.4

* Oligohaline mud habitat is not included in the calculations.

Table 4: Mean biomass for major habitat types.

Oligohaline Regime

	Fall 1978					Summer 1979				
	Annelids	Arthropods	Molluscs	Other	Total	Annelids	Arthropods	Molluscs	Other	Total
Mud	43.5	30.0	1.1	0.7	75.3	-	-	-	-	-
Mixed Sediment	41.9	10.2	1.1	-	53.2	46.4	2.3	4.2	5.4	58.3
Sand	5.1	9.5	0.8	-	15.4	7.8	3.8	-	-	11.6
*Overall	23.5	9.9	1	-	34.4	30.8	2.9	2.5	3.2	39.4

Mesohaline Regime

	Fall 1978					Summer 1979				
	Annelids	Arthropods	Molluscs	Other	Total	Annelids	Arthropods	Molluscs	Other	Total
Mud	37.7	13.2	237.0	0.8	288.7	124.2	24.5	663.8	5.9	818.4
Mixed Sediment	224.2	29.8	2335.8	0.7	2589.8	130.4	50.2	1236.4	2.0	1419.0
Sand	9.0	-	121.8	2.0	132.8	16.9	1.8	73.7	8.4	100.8
Overall	74.2	14.9	670.5	1.0	760.6	119.7	31.3	797.5	4.9	953.4

* Oligohaline mud habitat is not included in the calculations.

Table 5: Dominant benthic species in major habitats, ranked according to number of individuals: Based on Biological Index (McCloskey, 1970) and listed in order of importance.

Fall 1978			Summer 1979		
Oligohaline					
Mud	Mixed Sediment	Sand	Mud	Mixed Sediment	Sand
Leptocheirus plumulosus	Oligochaete spp.	Oligochaete spp.	?	Oligochaete spp.	*Chironomus* sp.
Scolecolepides viridis	*Leptocheirus plumulosus*	*Chironomus* sp.		*Scolecolepides viridis*	Oligochaete spp.
Cyathura polita	*Scolecolepides viridis*	*Clinotanypus* sp.		*Leptocheirus plumulosus*	*Cryptochironomus* sp.
Mesohaline					
Mud	Mixed Sediment	Sand	Mud	Mixed Sediment	Sand
Streblospio benedicti	*Macoma balthica*	*Streblospio benedicti*	*Macoma balthica*	*Macoma balthica*	*Streblospio benedicti*
Nereis succinea	*Streblospio benedicti*	*Heteromastus filiformis*	*Streblospio benedicti*	*Streblospio benedicti*	*Cerebratulus lacteus*
Paraprionspio pinnata	*Leptocheirus plumulosus*	*Macoma balthica*	*Leptocheirus plumulosus*	*Nereis succinea*	*Leptocheirus plumulosus*
Oligochaete spp.	*Nereis succinea*	*Cerebratulus lacteus*	*Nereis succinea*	*Leptocheirus plumulosus*	*Heteromastus filiformis*
Macoma balthica	*Heteromastus filiformis*	*Paraprionspio pinnata*	Oligochaete spp.	*Heteromastus filiformis*	*Mulinia lateralis*

Table 6: Dominant benthic species in major habitats, ranked according to biomass: Based on Biological Index (McCloskey, 1970) and listed in order of importance.

Oligohaline

Fall 1978			Summer 1979		
Mud	Mixed Sediment	Sand	Mud	Mixed Sediment	Sand
Scolecolepides viridis	*Scolecolepides viridis*	*Chironomus* sp.	?	*Scolecolepides viridis*	*Chironomus* sp.
Leptocheirus plumulosus	Oligochaete spp.	Oligochaete spp.		Oligochaete spp.	Oligochaete spp.
Cyathura polita	*Cyathura polita*	*Corbicula manilensis*		*Leptocheirus* sp.	*Cryptochironomus* sp.

Mesohaline

Fall 1978			Summer 1979		
Mud	Mixed Sediment	Sand	Mud	Mixed Sediment	Sand
Nereis succinea	*Macoma balthica*	*Macoma balthica*	*Macoma balthica*	*Macoma balthica*	*Mya arenaria*
Paraprionspio pinnata	*Nereis succinea*	*Heteromastus filiformis*	*Nereis succinea*	*Nereis succinea*	*Mulinia lateralis*
Macoma balthica	*Scolecolepides viridis*	*Cerebratulus lacteus*	*Scolecolepides viridis*	*Leptocheirus plumulosus*	*Heteromastus filiformis*
Streblospio benedicti	*Macoma phenax*	*Paraprionspio pinnata*	*Streblospio benedicti*	*Scolecolepides viridis*	*Cerebratulus lacteus*
Oligochaete spp.	*Heteromastus filiformis*	*Streblospio benedicti*	*Leptocheirus plumulosus*	*Macoma phenax*	*Macoma phenax*

Most species are numerically dominant in more than one habitat. Many of the numerical dominants were also classified as dominants based on biomass calculations.

Vertical Distribution of the Fauna

The vertical distribution of the benthic community is depicted for each habitat type (Figures 2-12). The mean number of individuals, species and biomass are represented by histograms. The solid line indicates the cumulative percent of the above parameters with depth. Dashed lines refer to average box core penetration within each habitat type. Average penetration for all stations was 39 cm. Penetration was most shallow in compact sands (15 cm), and most extensive in fluid muds (60 cm).

Sixty-five or more percent of the individuals occupy the upper 5 cm of the sediment strata and ≥85% are concentrated in the top 10 cm. The percent distribution of individuals in the oligohaline mixed sediments during both seasons differs from that of other habitats because of the number of deep-penetrating oligochaetous annelids. Nearly all the species collected from each habitat type (≥85%) were also found in the top 5 cm of the sediment.

All habitats, with the exception of the oligohaline sands, contain deep-dwelling fauna; namely those organisms living below 10 cm. Based on the number of individuals, deep-penetrating species within each salinity regime are most abundant in the mixed-sediment environments. Sands had the least number of deep-dwellers. Increases in the number of individuals and species from the oligohaline to the mesohaline regime are apparent when examining the same sediment types. The only exception to this trend occurs in the oligohaline mixed-sediment habitat (fall), where the number of individuals is greater than all other habitats.

Seasonal patterns are reflected in the surface and deep-dwelling populations. Total abundance decreased during the summer in the oligohaline regime but increased that same season in the mesohaline zone. Generally, the greatest density fluctuations can be attributed to species inhabiting the sediment surface. The deep-dwelling faunal component changed, but to a much lesser degree than its surface counterpart.

We have depicted the distribution of benthic biomass according to depth (Figures 2-12). Weight values are high in the top 5 cm of sands, variable throughout mixed sediments, and high below 5 cm in the muds. All substrates of the mesohaline zone had the highest weight values below 5 cm. The polychaetous annelid, Scolecolepides viridis, and the bivalve mollusc, Macoma balthica, are the primary biomass contributors in the oligohaline and mesohaline regimes, respectively.

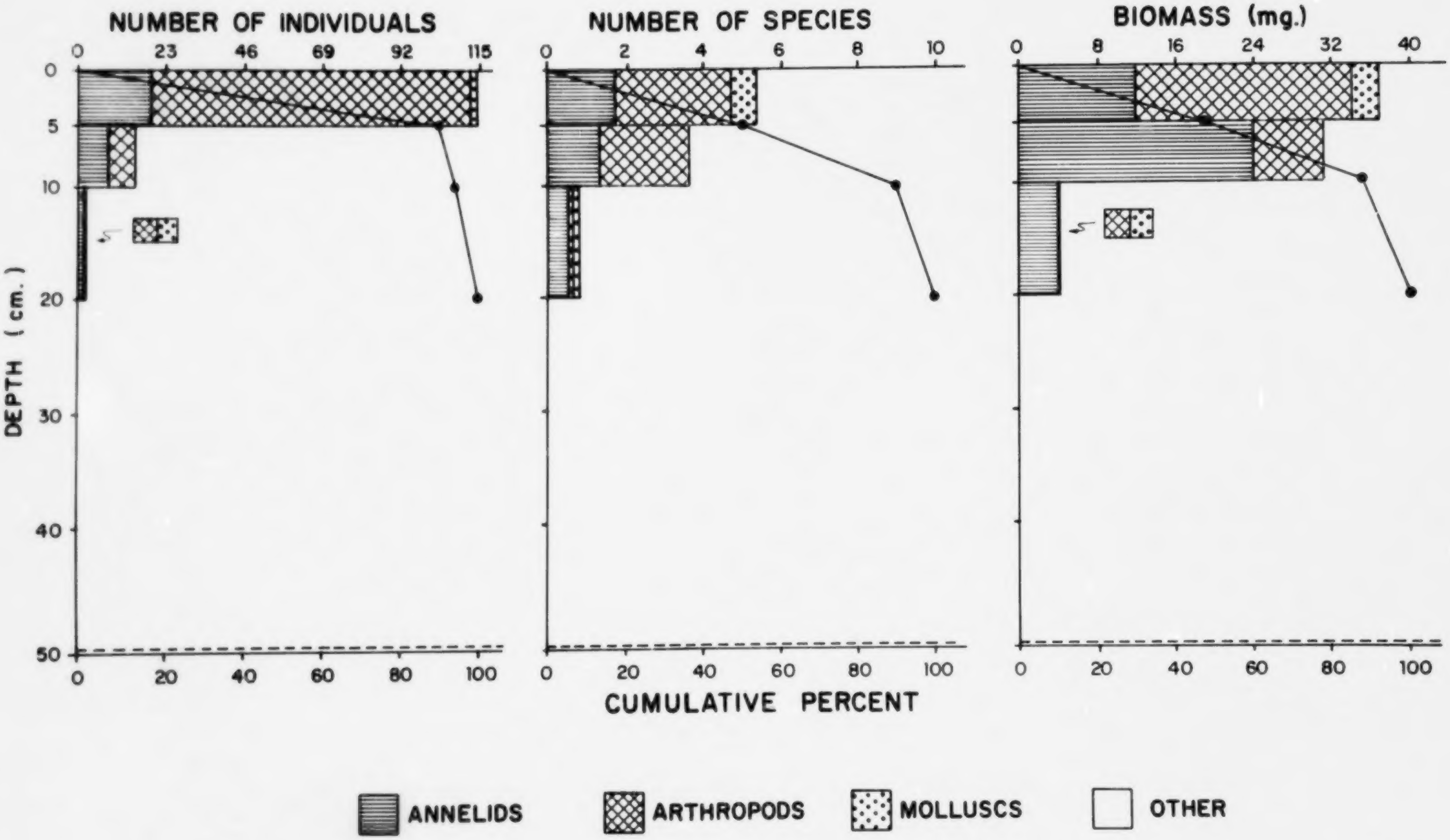

Figure 2: Vertical distribution of macrobenthos in the oligohaline, mud habitat (Fall 1978).

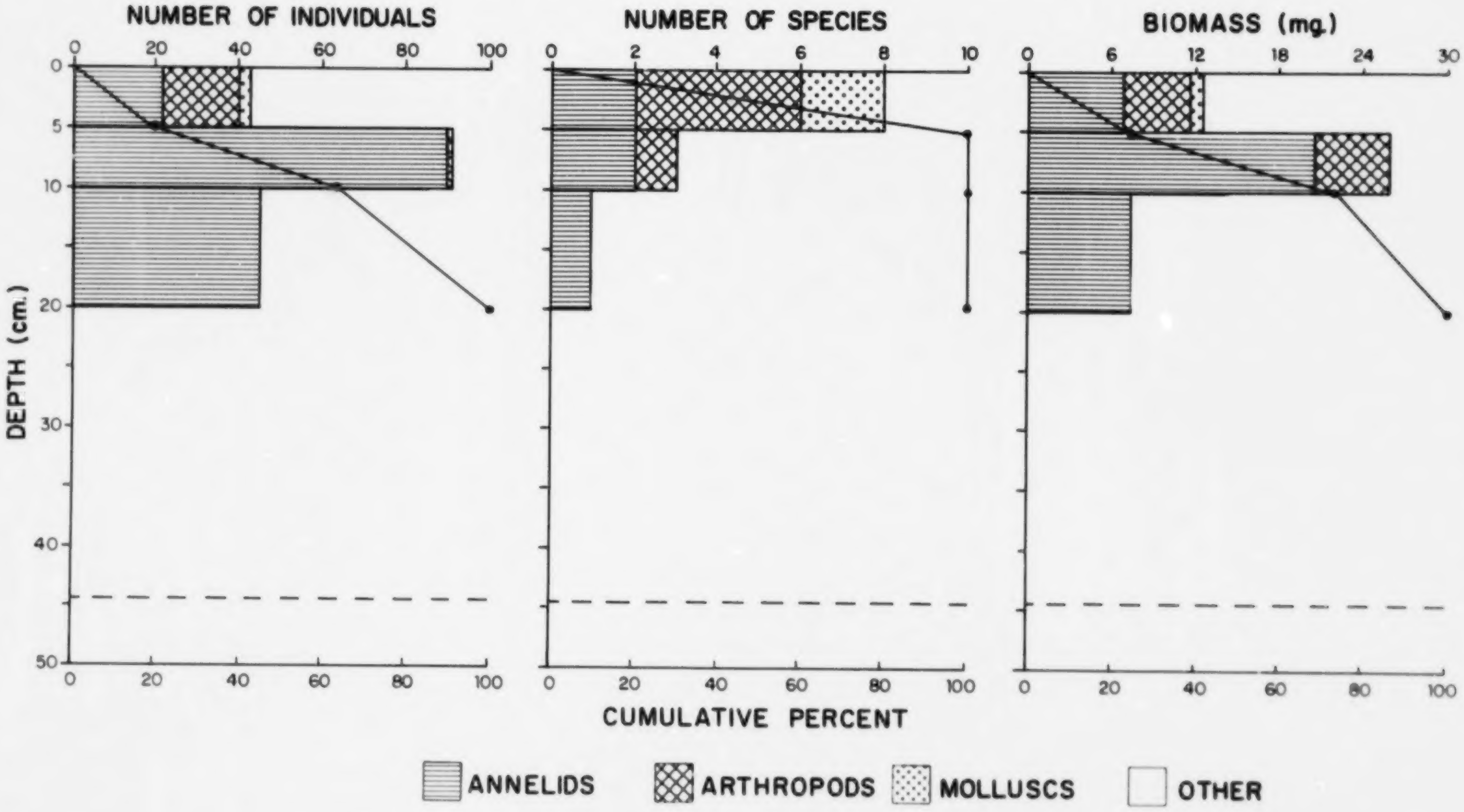

Figure 3: Vertical distribution of the macrobenthos in the oligohaline, mixed sediment habitat (Fall, 1978).

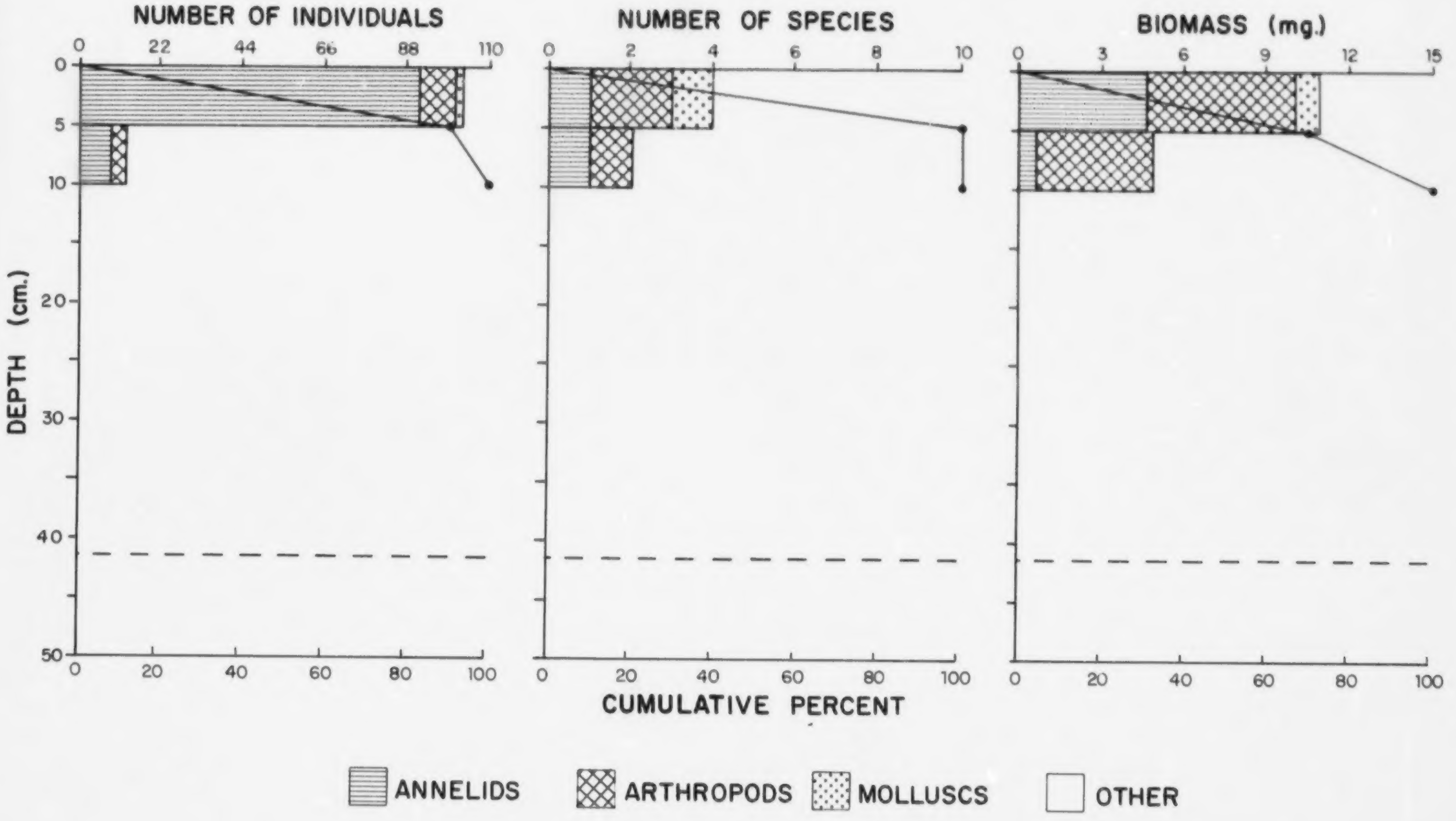

Figure 4: Vertical distribution of the macrobenthos in the oligohaline, sand habitat (Fall 1978).

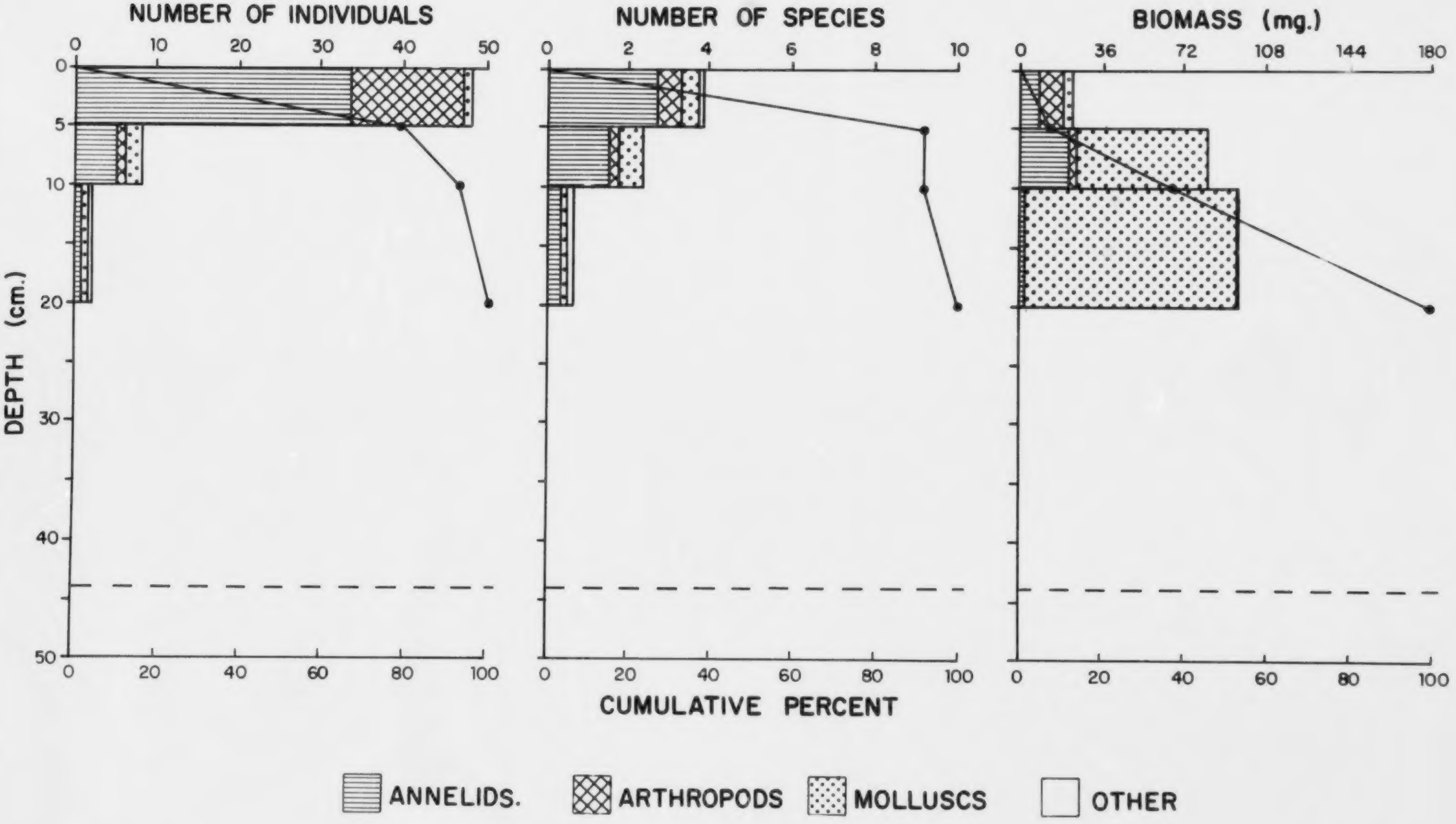

Figure 5: Vertical distribution of the macrobenthos in the mesohaline, mud habitat (Fall 1978).

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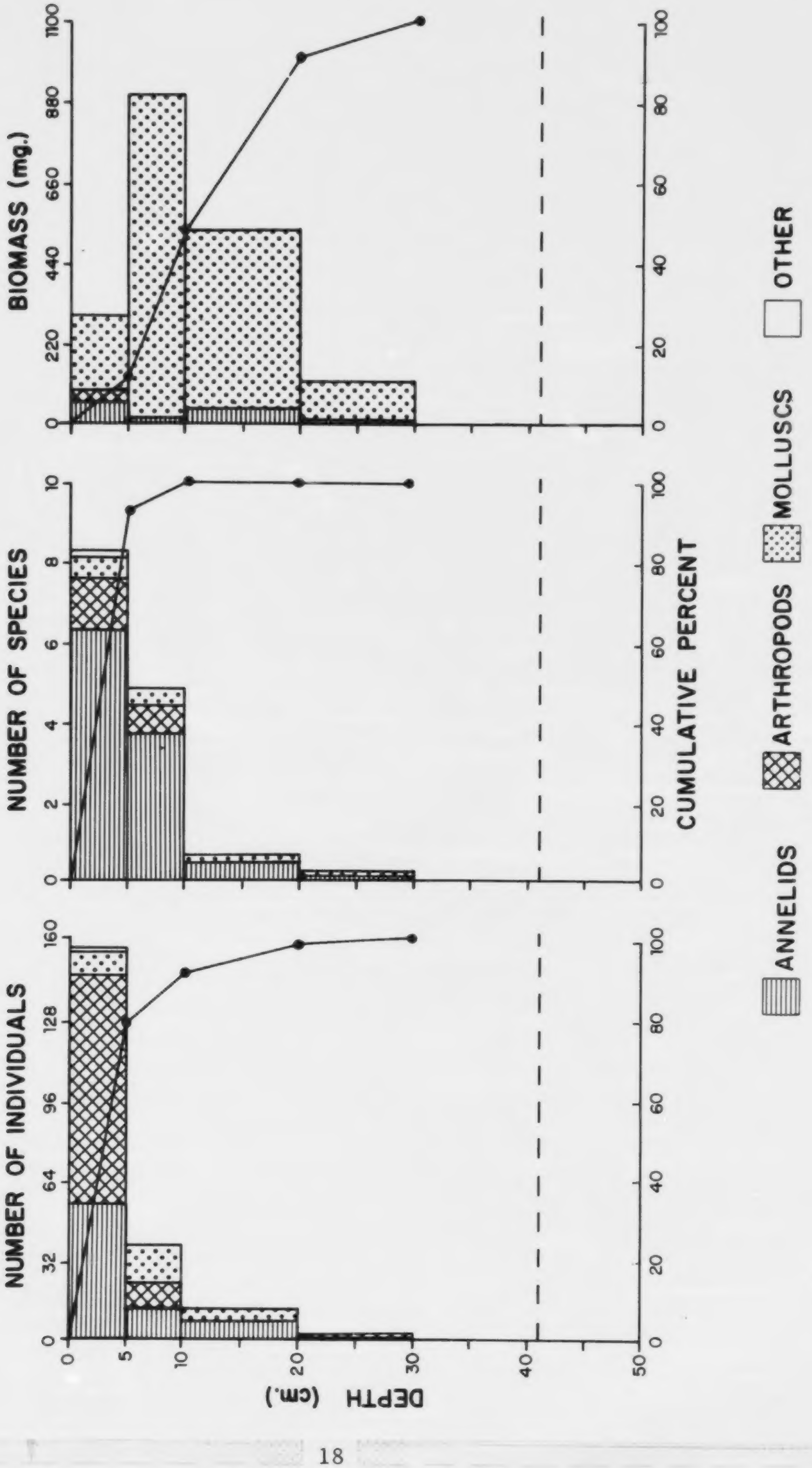

Figure 6: Vertical distribution of the macrobenthos in the mesohaline, mixed sediment habitat (Fall 1978).

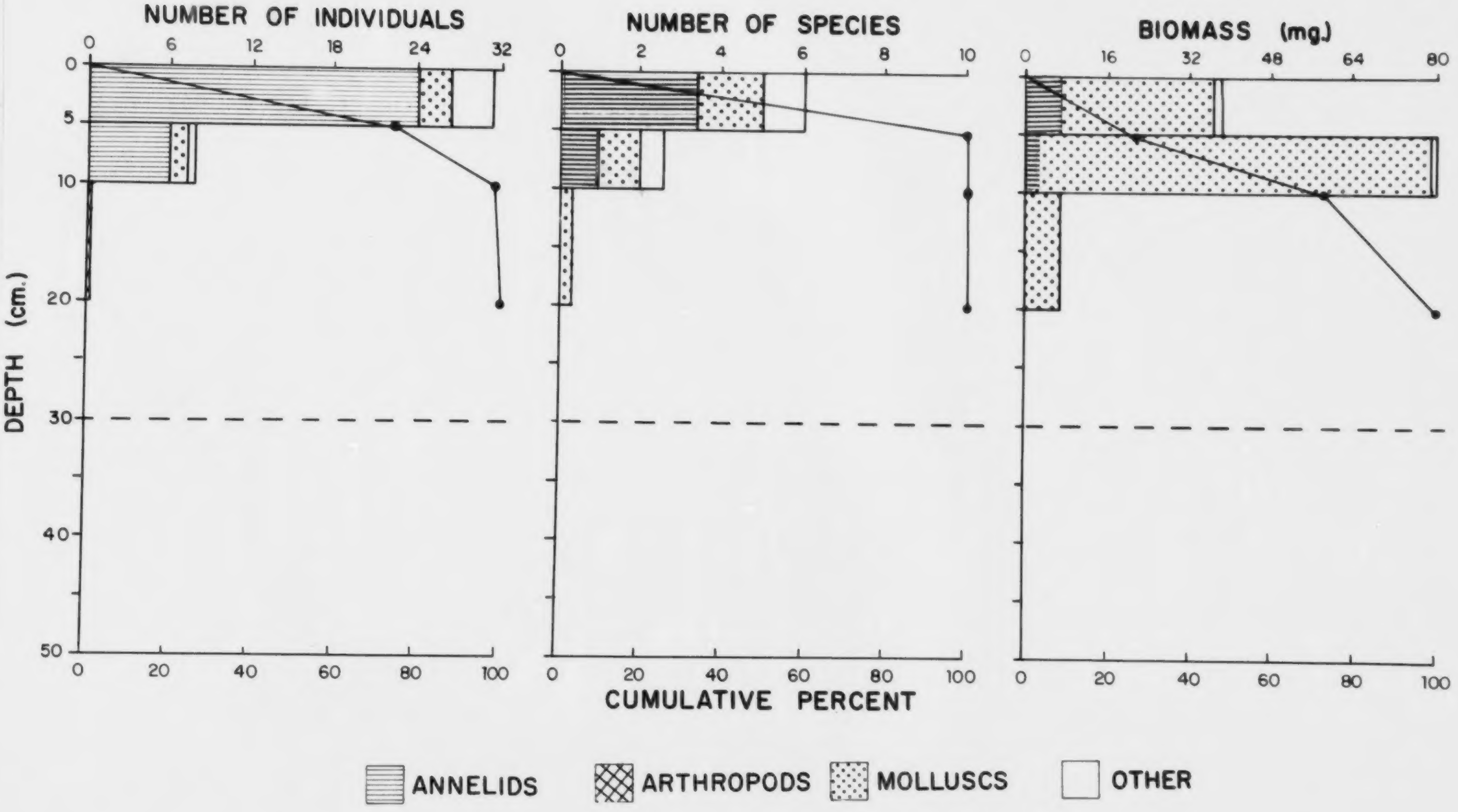

Figure 7: Vertical distribution of the macrobenthos in the mesohaline, sand habitat (Fall 1978).

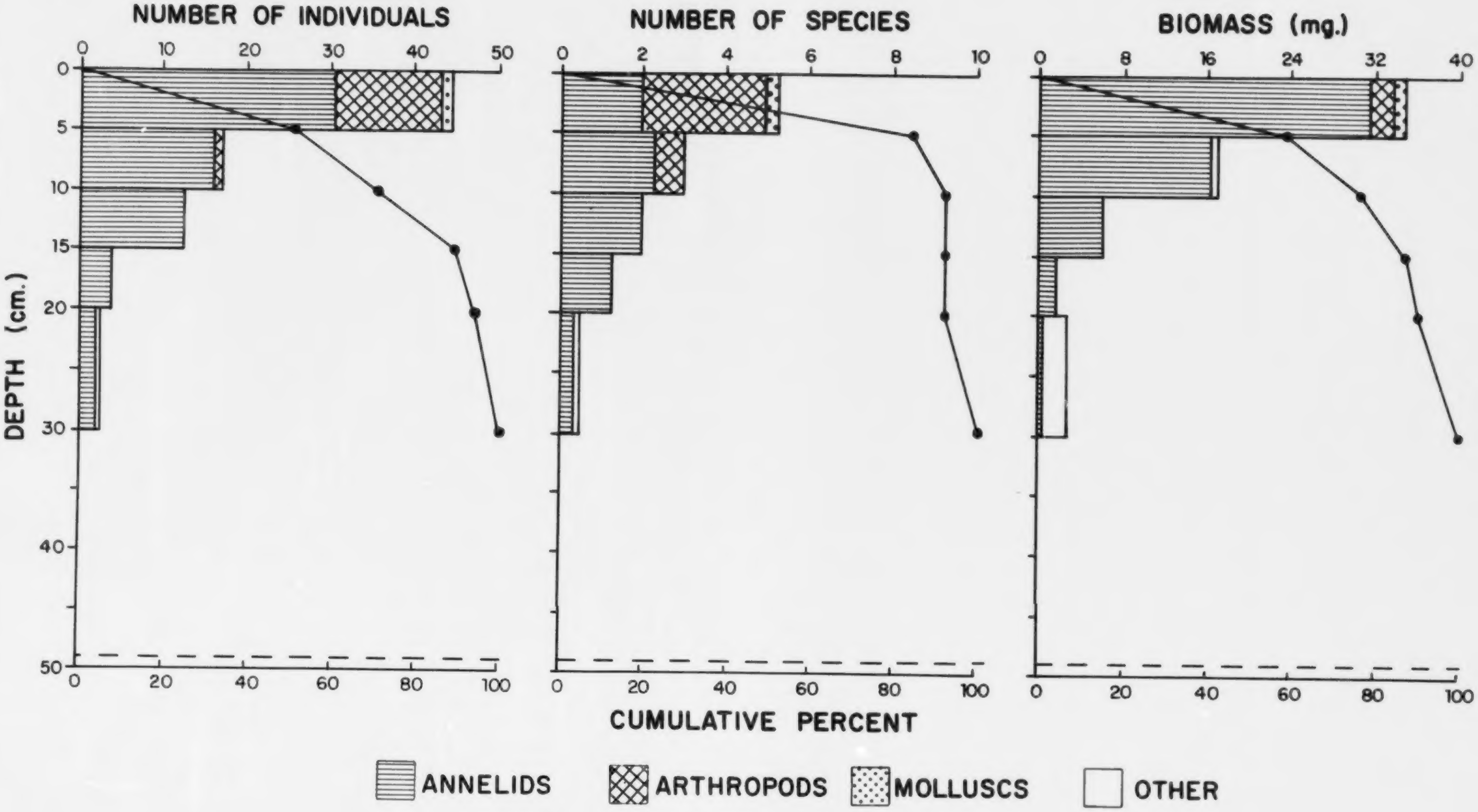

Figure 8: Vertical distribution of the macrobenthos in the oligohaline, mixed sediment habitat (Summer 1979).

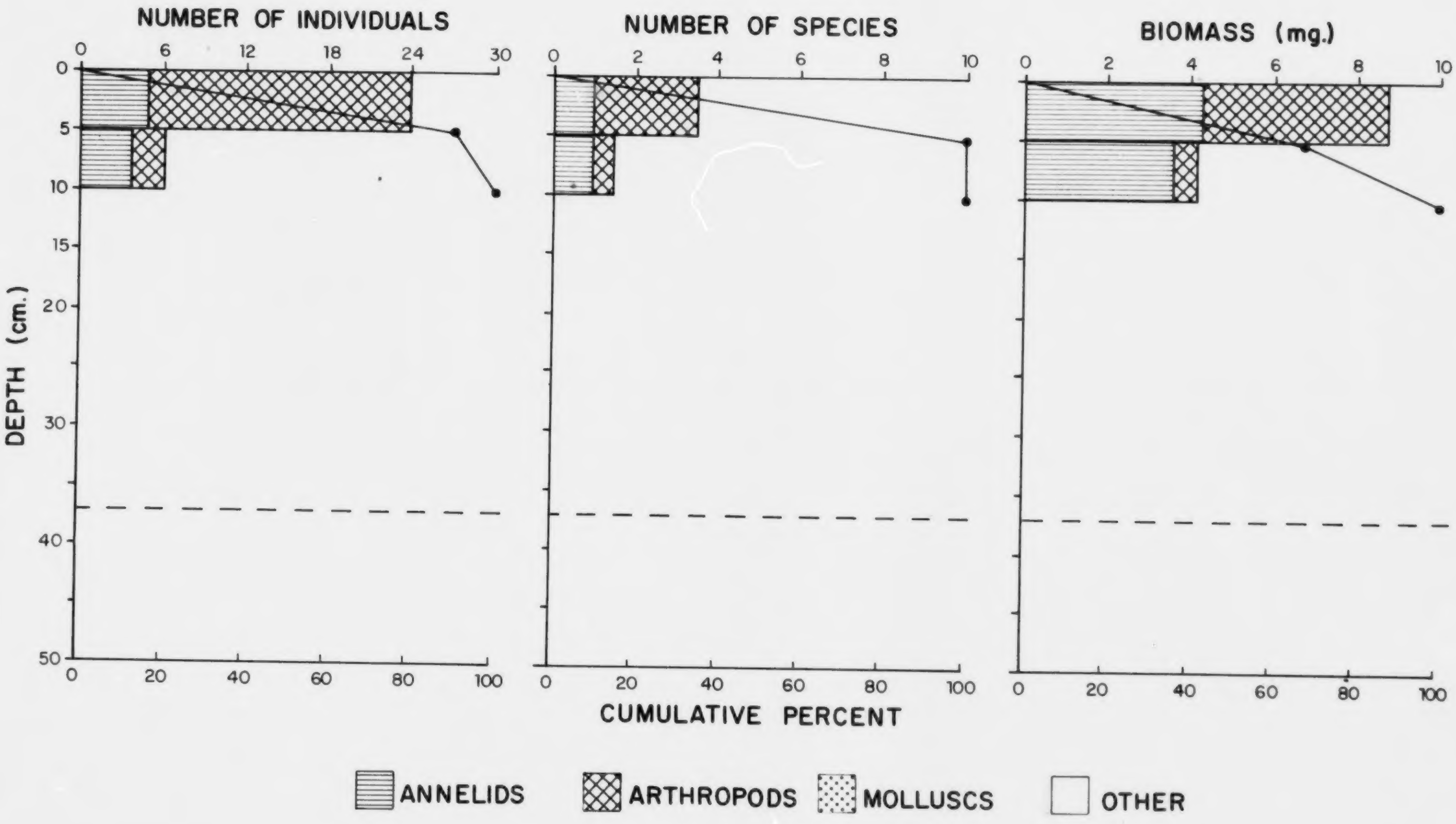

Figure 9: Vertical distribution of the macrobenthos in the oligohaline, sand habitat (Summer 1979).

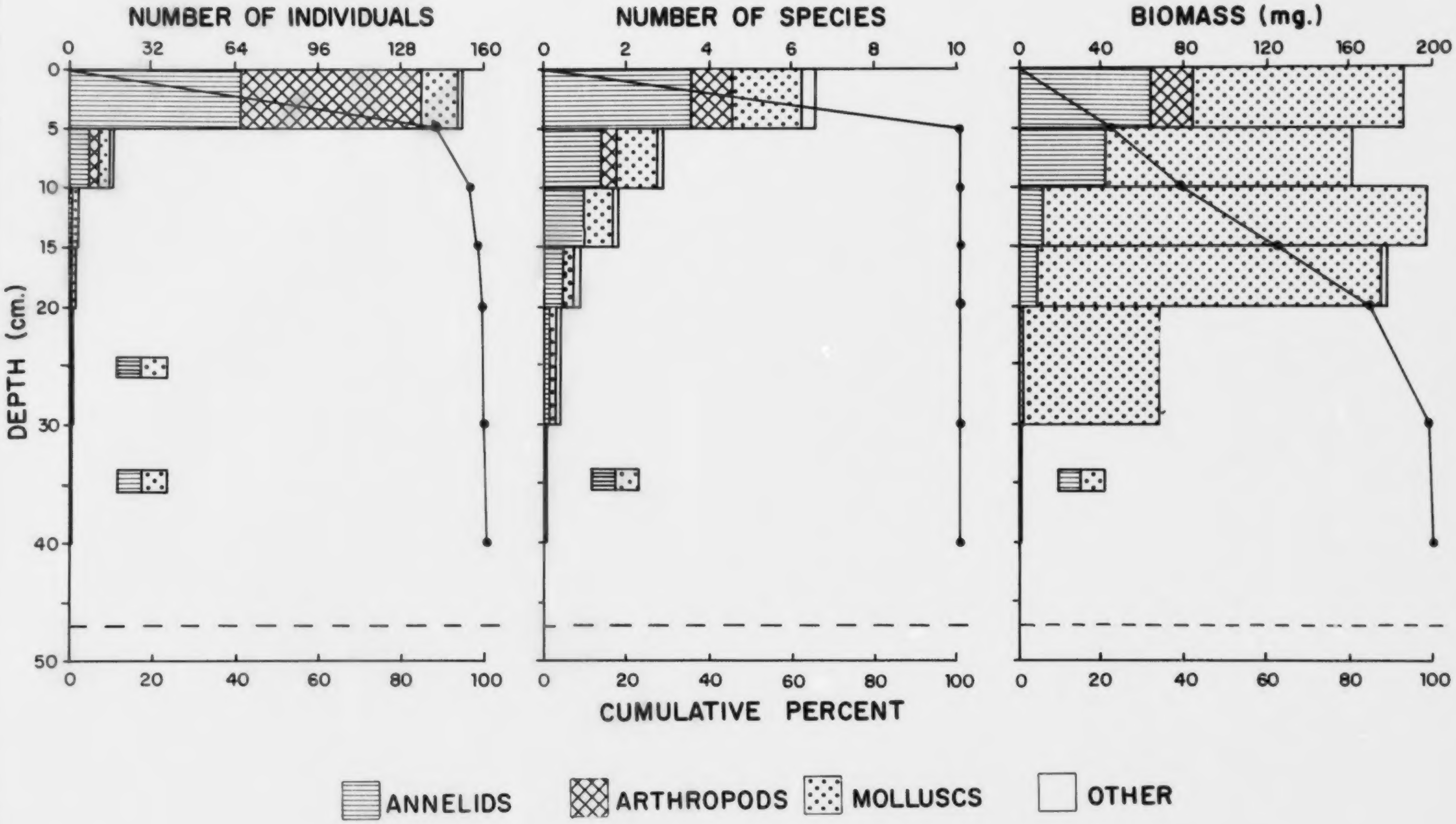

Figure 10: Vertical distribution of the macrobenthos in the mesohaline, mud habitat (Summer 1979).

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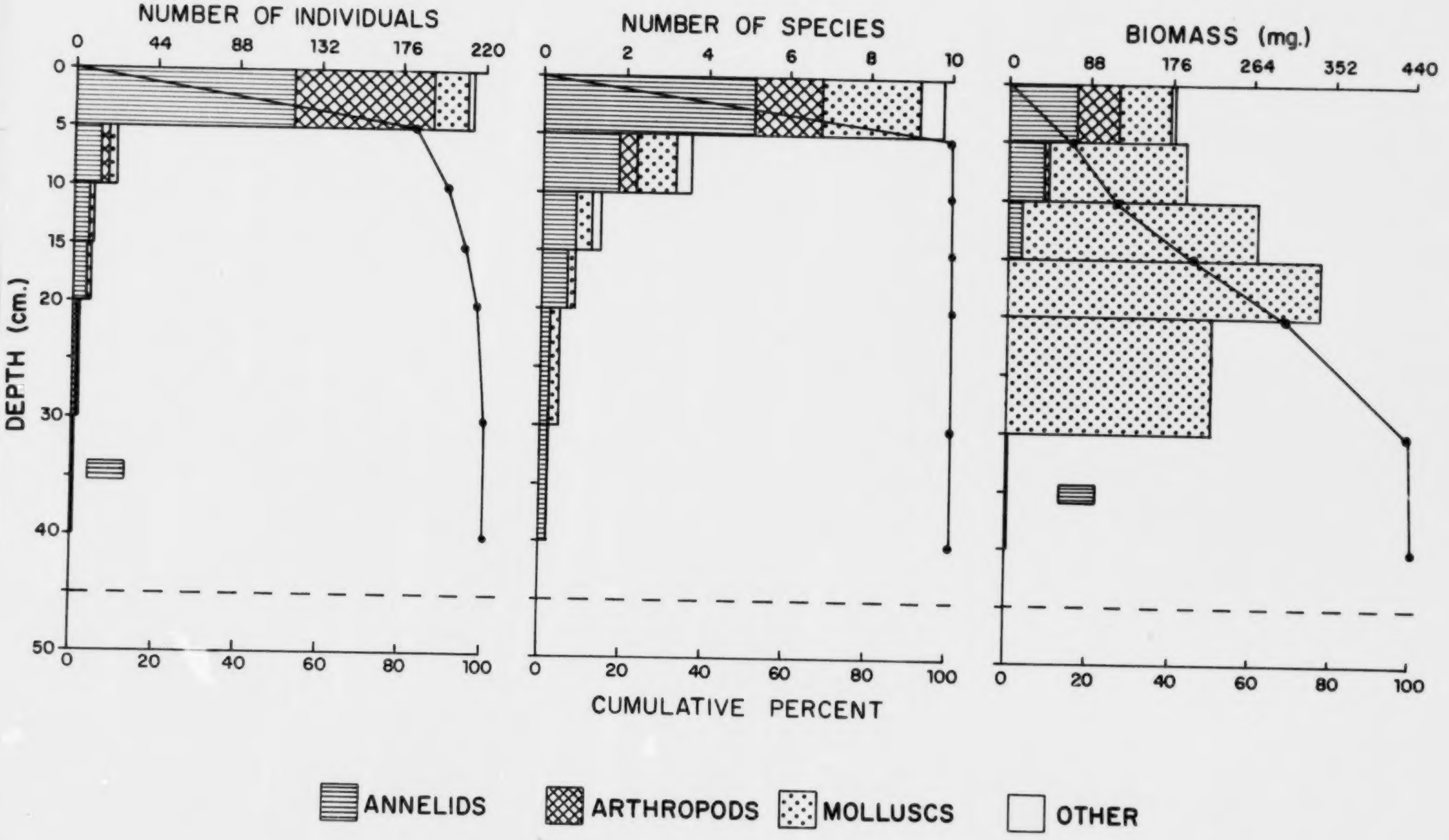

Figure 11: Vertical distribution of the macrobenthos in the mesohaline, mixed sediment habitat (Summer 1979).

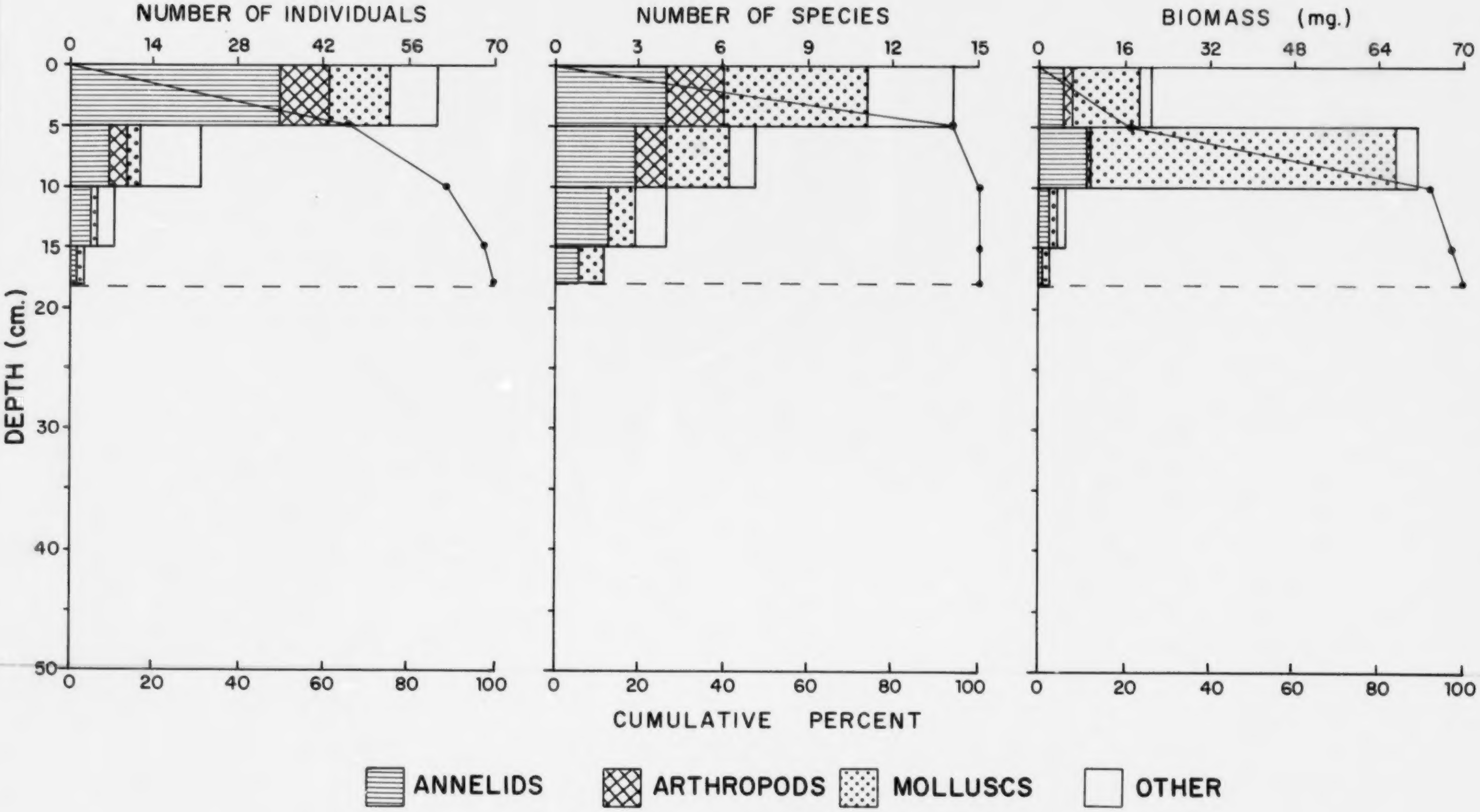

Figure 12: Vertical distribution of the macrobenthos in the mesohaline, sand habitat (Summer 1979).

Vertical Distrubution of Individual Species

Annelids are the most successful deep-dwelling group. A majority of the organisms are capable of penetrating deep into the sediment by constructing long tubes (e.g. - Paraprionspio, Scolecolepides) or burrows (e.g. - Glycera, Heteromastus, Nereis). These structures serve to maintain a connection with the sediment-water interface. Other annelids or worm-like species function as free burrowers which do not form permanent features (e.g. - oligochaetes, Cerebratulus). Certain bivalve molluscs (e.g. - Macoma) are also capable of extensive burrow-building by virtue of their long siphons. Unlike the annelids and molluscs, the arthropods are generally restricted to the sediment surface.

The distribution of dominant benthic species, based on numerical abundance, and maximum depth of penetration is outlined in Table 7. Many of the species, especially those of the mesohaline regime, are deep-dwelling organisms. Numerical dominants also occur as dominants based on biomass determinations (Table 8).

Several dominant species that live below 10 cm may comprise ≥10% of the total population. Among those organisms are the oligochaetes, the bivalve, Macoma balthica, and the polychaete, Heteromastus filiformis. These species are likely to be undersampled in studies employing conventional grab samplers that penetrate only to 10 cm below the sediment surface.

Many of the dominant species seem to have a preference for certain sediment strata despite their varied penetration ranges: the polychaete, Streblospio benedicti (0-2 cm); the insect, Chironomus sp., the amphipod, Leptocheirus polumulosus, and the isopod, Cyathura polita (0-5 cm); the polychaete, Heteromastus filiformis (5-10 cm); the polychaetes, Nereis succinea, Paraprionspio pinnata, and Scolecolepides viridis (0-10 cm); and the oligochaetes (0-15 cm). The adult bivalve, Macoma balthica generally preferred the 5-20 cm layer. Cerebratulus lacteus, a nemertean, had a random distribution. Findings similar to ours were noted for Heteromastus (Rosenberg, 1974) and the oligochaetes (Davis, 1974a).

Table 7: Dominant species based on numerical abundance in upper and central Chesapeake Bay (based on McCloskey's Biological Index, 1970) and maximum depth distribution.

Oligohaline Regime	Maximum Depth (cm)
1. Oligochaete spp.	30
2. *Leptocheirus plumulosus*	10
3. *Scolecolepides viridis*	20
4. *Cyathura polita*	10
5. *Chironomus* sp.	10

Mesohaline Regime	
1. *Streblospio benedicti*	5
2. *Macoma balthica*	30
3. *Nereis succinea*	30
4. *Leptocheirus plumulosus*	10
5. Oligochaete spp.	30
6. *Heteromastus filiformis*	40
7. *Paraprionspio pinnata*	15
8. *Macoma mitchelli*	20
9. *Scolecolepides viridis*	20
10. *Mulinia lateralis*	5

Table 8: Dominant species based on biomass in upper and central Chesapeake Bay (based on McCloskey's Biological Index, 1970).

Oligohaline Regime

1. Scolecolepides viridis
2. Oligochaete spp.
3. Leptocheirus plumulosus
4. Cyathura polita
5. Chironomus sp.

Mesohaline Regime

1. Macoma balthica
2. Nereis succinea
3. Streblospio benedicti
4. Macoma mitchelli
5. Leptocheirus plumulosus
6. Heteromastus filiformis
7. Paraprionspio pinnata
8. Scolecolepides viridis
9. Mulinia lateralis
10. Oligochaete spp.

3. Bioturbation and Sedimentary Structures

Radiography has been used to illustrate sedimentary features indicative of physical and biological conditions. Information regarding sedimentary structures, sediment textures and biogenic features for each station has been transcribed onto three-dimensional schematics (Appendix IV). A number of radiographs that are representative of the various sedimentary environments in the upper and central Chesapeake Bay are included in this report (Appendix V). The degree of bioturbation is defined as the percentage of disturbance observed in the radiographs and follows the scheme of Howard and Frey, 1972. Almost all of our samples showed some evidence of bioturbation (Table 9).

Physical Structures and Sediment Textures

The distribution of sediments and the formation of sedimentary structures in the Chesapeake Bay is controlled by hydrodynamic conditions as well as the availability of sediments. Although some structural overlap occurs between sediment types, most substrates have characteristic physical sedimentary features (Table 10). Since the biotic and abiotic components of the substratum are inextricably bound, these physical structures may be subject to destruction, resulting in bioturbated textures.

The bottom sediments of the upper and central Bay area cover the entire textural spectrum. Substrate classification was consistent with the scheme presented earlier in this report (refer to Results, 2. Abiotic Environment). Sandy environments, however, were further categorized into medium to coarse and fine sands.

Coarse to medium sands are found in relatively high energy regimes, particularly at the head and nearshore flanks of the estuary. Station 1 (Plate 1) is located at the mouth of the Susquehanna River and is representative of the sand flats region. The intensity of the physical setting is demonstrated by the presence of large-scale cross-bedding patterns. Pebbles and shells are scattered throughout the substratum. Negligible biogenic effects are imparted on the sedimentary environment due to the small size and transient nature of the fauna.

The second substrate type, fine sand, is generally confined to the nearshore margins just beyond the coarser sands. Sheets of fine sand reaching approximately 20 cm in depth overlie a hard clay substratum. Small-scale cross-bedding and shell lamination characterize these mobile, low organic substrates (Station 12, Plate 2). Shell layers are typically heterogenous and accumulate primarily as a result of high current energies. Sedimentary features are rarely preserved in this environment as a consequence of general bioturbation activities.

The transitional mixed-sediment substrates occur in a variety of energy regimes. In these sediments, interbedded mud and sand appear to be the dominant physical pattern. This interlayered sequence is most clearly evident in the upper Bay. Station 2 (Plate 3), for example, is situated below the Susquehanna flats region. The bottom sediments in this area are influenced by

Table 9: Bioturbation levels for sampling stations based on the classification scheme of Howard and Frey, 1972.

Degree of Bioturbation	Stations		
0	1,51		
trace		55,58,62	
<30	2,4,52,53	12,57,64	21,24
30-60	3,5	8,14,18,19	
60-90		7,56,59,61	22,23
90-99		6,9,10,11,13 15,16,17,54, 60,63	20,25,65
100			
	Oligohaline	Mesohaline	Meso-polyhaline
		Salinity Regime	

Table 10: Physical Structures Found Within Various Sedimentary Environments (Based on the classification scheme of Reineck and Singh, 1975)

Sediment Textures	Dominant Physical Structures	Associated Physical Structures
Medium-coarse sand	Large-scale cross-bedding (rippled trough and planar bed sets)	Mud flasers Inclusions (pebbles, shells, mud balls, coal)
Fine sand	Small-scale cross-bedding (rippled trough-shaped bed sets)	Mud flasers Inclusions (shell and shell fragments)
Mixed sediment	Interbedded mud and sand	Small-scale ripple lamination Mud flasers Wavy bedding Sand lenses Scour-and-fill structures Inclusions (shells and shell fragments)
Mud	Laminated mud beds (planar and wavy bed sets)	Sand partings Inclusions (shells, slag)

variable current dynamics and the turbidity maximum (Schubel, 1968). This area has a low species diversity with only the tube traces of a single species apparent in the radiograph. Biological activity is minimal and inconsequential when compared to the environmental dynamics of the region. Recent physical activity, for instance, has obliterated all biogenic features in the upper 5 cm of the substratum.

Shell aggregations in mixed-sediment substrates are common. These assemblages may be homogenous, reflecting mass mortalities of benthic species. Such mortalities combined with current transport produce more heterogenous shell concentrations.

The mud environment lies beyond the transitional mixed sediment zone and extends to the deep-water channels. Physical structures, such as laminated mud bedding, become evident in the progression to deeper waters. The mud laminae are most distinct in the channel regime. Station 55 (Plate 4) is located near the Bloody Point area at a depth of 31.45 m. This radiograph illustrates the complex and variable nature of some channel areas. Mud beds with sand lenses overlie thick bedded sand-mud layers; this sediment probably representing coastal plain deposits. The sand partings are indicative of temporary high energy surges. The mud laminae may be destroyed because of the upward migration of great quantities of methane gas (Martin and val Klump, 1980). Death assemblages (some individuals preserved in the living position) of the mactrid bivalve, Mulinia lateralis, reflect episodes of mass mortality resulting from anoxia or intermittent bottom resuspension and redeposition.

Biogenic Structures

The benthic macrofauna can have a significant effect on the bottom environment where physical processes do not prevail. Organisms may bioturbate or otherwise rework the substratum through feeding, biodeposition and irrigation. The types of biogenic structures produced by the biota are, in part, indicative of their influence on the sediment. Biogenic features in the Chesapeake Bay include (a) dwelling tubes, (b) well-defined burrows which serve as dwelling and feeding structures, and (c) feeding traces which facilitate the general bioturbation of the substratum.

Biogenic profiles have been developed for commonly encountered species in the upper and central Chesapeake Bay (Table 11). The majority of biological structures are produced by polychaetes. The most conspicuous features include the polychaete tube traces of Scolecolepides viridis in the oligohaline regime; the polychaete burrow system of Nereis succinea as well as the bivalve burrow of Macoma balthica in the mesohaline regime and the polychaete burrow system of Glycera dibranchiata in the high meso- and meso-polyhaline regime. Biodepositional features, such as fecal mounds of the polychaetes, Nereis succinea and Heteromastus filiformis, are occasionally seen at the sediment surface; however, most are presumably destroyed by microbial degradation and transported by tidal currents.

Many of the radiographs (≈60% of the stations) display little or no physical stratification. Most of these highly bioturbated cores are located in the meso- and meso-polyhaline regimes where a greater diversity of potential biogenic reworking species exist. Sediments which are located in shallow regions ($\leq$10 m) tend not to suffer from anoxic conditions, thus allowing animal populations to establish and maintain themselves. Therefore, these substrates are likely to be dominated by biologically-produced features.

Biogenic structural diversity is greatest in stable mud environments. Permanent tubes and burrows create a complex geometry of galleries throughout the sediment (Station 63; Plate 5). Most biogenic structures are large. Apparently smaller features are destroyed by bioturbation activities. A number of occupied structures have a rust-colored lining which are occasionally visible as light halos in the radiographs. The color variation is the result of irrigation of the dwelling sites. Dissections often indicate that abandoned biogenic features are usually back-filled with fine-grained material; nevertheless, some remain open.

Unlike the stable muds, sand environments have a more homogenous appearance (Station 25; Plate 6). Back-filled structures are usually lacking. Only actively maintained tubes and burrows are evident.

Anthropogenic Effects

Anthropogenic influences may mask the effects of natural physical processes or the activities of the biota. The effects of human activity may be destructive as exhibited in the disruption of physical structures at Station 52 (Plate 7). Propeller-generated turbulence from concentrated ship traffic to and from the C&D Canal is apparently the cause of this physical mixing of formerly distinct interlayered mud, sand and shell laminations. Man-induced effects may also result in the formation of various sedimentary beds. The alternating mud-sand fabrics depicted at Station 7 (lower half of Plate 8) resulted from episodic dumping of dredged material. The most recent disposal (23-30 cm) was due to the dredging of Baltimore Harbor in 1965 by the Army Corps of Engimeers (personal communication).

Table 11: Biogenic profiles developed for commonly encountered species in the upper and central Chesapeake Bay, oligohaline to meso-polyhaline transition zone.

Species	Environmental Distribution	Depth of Penetration	Feeding Type	Biogenic Structure/ Activity	References
Nemertea					
Cerebratulus lacteus	Euryhaline, all sediment types	30 cm	Predator	Free burrower	Boesch, 1973 Howard and Frey, 1973
Mollusca					
Bivalve					
Macoma balthica	High oligo- to mesohaline, all sediments but prefers mud environments	30 cm	Selective deposit feeder (surface), occasionally suspension feeds	Burrow builder (unlined, usually vertically oriented), irrigation, pelletization	Stanley, 1970 Bubnova, 1972 Wolff, 1973 Risk and Moffat, 1977
Macoma mitchelli	Mesohaline, all sediments	20 cm	Selective deposit feeder (surface)	Burrow builder(?)	
Mulinia lateralis	Mid-meso to euhaline, all sediments but more common in finer types	5 cm	Suspension feeder	Free burrower, produces funnel-shaped depressions	Stanley, 1970 Frey and Howard, 1972 Boesch, 1973
Annelida					
Oligochaeta					
Oligochaete spp.	Oligo- to polyhaline, all sediment types	30 cm	Non-selective deposit feeder (sub-surface)	"conveyor-belt" species	Davis, 1974a Fisher, et al., 1980
Polychaeta					
Glycera dibranchiata	High meso- to polyhaline, all sediment types	30 cm	Non-selective deposit feeder, predator	Burrow builder (mucus lines, winding burrow system), irrigation	

Table 11: Biogenic profiles (cont.)

Species	Environmental Distribution	Depth of Penetration	Feeding Type	Biogenic Structure/ Activity	References
Annelida					
Polychaeta					
Glycinde solitaria	Meso- to polyhaline, all sediment types	5 cm	Predator	Free burrower	
Heteromastus filiformis	Euryhaline, all sediment types	40 cm	Non-selective deposit feeder	Burrow builder (mucus lined, simple long or repeated bifurcating system), irrigation, "conveyor-belt" species, fecal mounds	Howard, et al., 1972 Howard and Frey, 1975 Myers, 1977 Cadee, 1979 Fauchald and Jumars, 1979
Nereis succinea	High oligo- to euhaline, all sediment types	30 cm	Non-selective deposit feeder	Burrow builder (mucus lined, simple U-shaped to complex irregular system), irrigation, fecal mounds, ingestion-egestion	Bloom, et al., 1972 Wolff, 1973 Howard and Frey, 1975 Mayou and Howard, 1975 Cammen, 1980
Paraprionspio pinnata	Mid-meso- to polyhaline, all sediment types with preference for mud environments	15 cm	Selective deposit feeder (surface)	Tube builder (mucus)	Boesch, 1973 Fauchald and Jumars, 1979
Pectinaria gouldii	High meso- to euhaline, all sediment types	5 cm	Selective deposit feeder (sub-surface)	Mobile tube builder (cone-shpaed sand tube), creates feeding trace at base, "conveyor-belt" species, 400 ml sed/worm/yr	Gordon, 1966 Rhoads, 1967 Hertweck, 1972 Whitlach, 1974

Table 11: Biogenic profiles (cont.)

Species	Environmental Distribution	Depth of Penetration	Feeding Type	Biogenic Structure/ Activity	References
Annelida Polychaeta					
Scolecolepides viridis	Oligo- to low mesohaline, all sediment types with preference for mixed-sediment environments	20 cm	Selective deposit feeder (surface)	Tube builder (mucus)	
Streblospio benedicti	Euryhaline, all sediment types	5 cm	Selective deposit feeder (surface)	Tube builder (mucus, fragile)	Fauchald and Jumars, 1979
Arthropoda Amphipoda					
Ampelisca abdita	High meso- to polyhaline, mud to fine sand	5 cm	Selective deposit feeder (surface)	Tube builder (mucus), potential sediment stabilizer	Mills, 1967 Lynch and Harrison, 1969
Leptocheirus plumulosus	Oligo- to mesohaline, mud to muddy sands	10 cm	Omnivore, surface forager	Burrow builder (unlined)	Sanders, et al., 1965
Isopoda					
Chirodotea caeca	Euryhaline, all sediment types	5 cm	Omnivore	Free burrower	Bowman, 1955
Cyathura polita	Oligohaline, all sediment types	10 cm	Omnivore, surface forager	Burrow builder (unlined)	Burbanck, 1962 Burbanck, 1967
Phoronida					
Phoronis sp.	High meso- to polyhaline	15 cm	Suspension feeder	Tube builder (sand encrusted)	

DISCUSSION

Benthic Community Composition

Our scheme of the composition of the benthic community of the upper and central Chesapeake Bay is comparable to that of other studies in this estuarine system (Pfitzenmeyer, 1970 & 1975; Boesch, et al., 1976; Holland et al., 1977; Mountford, et al., 1977; Loi and Wilson, 1979). The macrofauna are numerically dominated by estuarine endemic and opportunistic species. Although differences occur in the dominant faunal assemblages between salinity regimes and substrate types, most of these species populate a wide range of salinities and sediment textures. The ubiquitous and variable nature of these species makes it difficult to ascertain the environmental influences. Other factors besides salinity and sediment texture must be examined in order to clearly delineate animal-sediment relationships.

Recent studies of the Chesapeake Bay show the variable nature of the substrata. Sediment transport from river mouths and shoreline erosion result in changing patterns of deposition and erosion (Table 12). Most areas of the Bay display relatively small changes in sedimentation. High sediment variations were found along the channel slopes. Despite the apparent generality of these findings, they help to contribute to a more accurate assessment of environmental disturbances when correlated with Pb^{210} data and the radiographic information. The greatest physical influences on the sedimentary environment are noted in the upper area of the estuary and along the channel regime.

The significance of intermittent sediment instability on the benthic community has been discussed by McCall (1977) and Rhoads, et al. (1978). "Instability", for the purposes of this report, refers to natural disturbances (storms, strong tidal currents) or anthropogenic effects (dredging and spoil disposal). Using defaunated sediments, these researchers have outlined a faunal succession beginning with early colonizing, surface-dwelling opportuists and culminating with deep-dwelling, equilibrium species.

Application of the results from the above authors to communities found in the Chesapeake Bay is difficult. Faunal components of both successional stages are found in most areas. The lack of equilibrium conditions for benthic communities in the Bay is indicative of intermittent disturbances. The character of the benthic fauna in the sand flats region of the upper Bay (oligohaline, sand habitat containing surface-dwelling chironomids and oligochaetes) and some deep-water regimes (containing surface-dwelling polychaetes), however, suggests a perpetual state of opportunism as a result of continuous disruptions.

Table 12: Sedimentation patterns and Pb^{210} rates for box core stations.

Station No.	*Sedimentation Pattern	** Pb^{210} Rates
(Fall 1978)		
1	-	-
2	-	-
3	+/-	-
4	-	3.1 mm/yr
5	-	-
6	+/0/-	8.8 mm/yr
7	+	-
8	+	-
9	-	-
10	-	-
11	-	-
12	+/0/-	-
13	+	-
14	+	0.7 mm/yr
15	-	-
16	0	-
17	+	-
18	+	3.8 mm/yr
19	+	-
20	No Data	-
21	No Data	-
22	No Data	-
23	+	-
24	+/0/-	12.4 mm/yr
25	0	-
(Summer 1979)		
1	-	-
2	-	-
6	+/0/-	8.8 mm/yr
7	+	-
8	+	-
13	+	-
14	+	-
15	-	-
21	No Data	-
23	+	-
24	+/0/-	12.4 mm/yr
25	0	-
51	+	-
52	No Data	2.0 mm/yr
53	0	-
54	-	-
55	++	17.8 mm/yr
56	-	-
57	+	-
58	++	-

Table 12: Sedimentation patterns and Pb^{210} rates (cont.)

Station No.	*Sedimentation Pattern	** Pb^{210} Rates
(Summer 1979)		
59	-	-
60	+/0/-	1.6 mm/yr
61	+	-
62	+	12.6 mm/yr
63	-	4.1 mm/yr
64	No data	11.5 mm/yr
65	No Data	-

+	Low Deposition
++	Moderate Deposition
+++	High Deposition
0	No change
-	Low Erosion
--	Moderate Erosion
---	High Erosion

* Data gathered from distribution of sediments and sedimentation budgets, R. Kerhin and J. Halka (1981), Maryland Geological Survey, Baltimore, Maryland (unpublished).

**Information collected from G. Setlock (1980), University of Maryland, College Park, Maryland (unpublished).

Vertical Distribution Patterns

Most of the benthic macrofauna in the upper and central Chesapeake Bay are found in the top 10 cm of the sediment, with penetration to 30 cm or more. This finding is consistent with numerous other studies (Holme, 1953; Lie and Pamatmat, 1965; Johnson, 1967; Rhoads, 1970; Smith and Howard, 1972; Rosenberg, 1974). Both the number and life style of the benthos varied according to habitat and season.

Food is abundant in the mud environment (Hamilton and LaPlante, 1973). Food particles may be found at depth but most of the readily assimilated material is concentrated at the surface in the form of decaying fecal matter, the vestiges of microbial colonization and degradation (Dale, 1974; Johnson, 1974; Fenchel, 1972; Johnson, 1977; Aller and Yingst, 1978). Unlike the food supply, oxygen availability is limited; the oxidized zone begins within a few mm of the sediment surface. Low oxygen conditions and sediment compaction in some muddy regimes make burrowing difficult. Most organisms in this environment are found near the surface or maintain a connection with the sediment-water interface. These benthos must be tolerant of low oxygen conditions and possibly toxic hydrogen sulfide, a substance associated with anoxia. This physiological adaptation is especially critical during the summer in depths $\geq$10 m when anoxic conditions in the Bay are prevalent (Taft, et al., 1980). The fauna in "end stress" environments, those areas with unstable fluid muds, are restricted to the surface. Species in these unfavorable conditions cannot establish and maintain themselves because of periodic anoxia and their inability to preserve a connection with the sediment-water interface.

Unlike the mud environments, food availability in sands is more limited. Oxygen, however, tends to saturate sands because of the greater permeability of the sediment. These factors in turn allow a more motile fauna to exist deep in the sediments without a connection to the sediment surface.

Food and oxygen availability plus other factors (e.g.-physiochemical) may function alone or in concert to create the distribution patterns depicted. More deep-dwelling individuals inhabit the mixed-sediment environments than in other regions. This sediment regime does not usually undergo periods of anoxia, and has a large and varied array of potential food particles. The lack of greater penetration in the sand environments can be attributed to continuous physical disturbance in the oligohaline regime, and the existence of an underlying hard clay substratum, 10-20 cm below the fine sand sediment surface, in the mesohaline regime.

Within the same sediment environment, there was a general increase in the number of deep-dwelling organisms from the oligohaline to the mesohaline regimes, this increase is simply a reflection of a larger number of species in the mesohaline zone. There is a larger number of species with greater depth ranges in the central than in the lower Bay (refer to VIMS final report). This trend is comparable to the nearshore-offshore relationships expressed by Howard and Frey (1975). Most species in the nearshore and the central Bay regimes penetrate deep in the sediment in in response to a highly fluctuating environment at the sediment-water interface.

Temporal as well as spatial vertical distribution patterns were noted for the upper and central Chesapeake Bay. The number of individuals for most species increased during the summer. This increase is usually due to the recruitment of juvenile, surface-dwelling species in the spring which are subsequently reduced in the summer by a number of factors: physical (Rhoads, 1974) and biological (Virnstein, 1977 & 1979; Hollands, et al., 1980). The anomolous total density pattern of the number of individuals in the oligohaline regime suggests fall recruitment by oligochaetes.

Many of the deep-dwelling organisms in the various habitats were polychaetes, but a few mollusc species were also represented. These species (e.g. - Glycera, Heteromastus, Macoma, Nereis, Paraprionspio, Scolecolepides) display a tolerance for low oxygen and high temperature conditions (refer to Odhner, 1978 for general overview). The above organisms further demonstrate wide and varied feeding habits. These adaptations allow for survival in the face of changing environmental conditions. The fact that a majority of the deep-dwellers are also numerical and biomass dominants lends credence to the stability hypothesis espoused by Copeland (1970) and Boesch (1974). Briefly, a population dominated by ubiquitous, deep-dwelling species is more tolerant of environmental perturbations than their surface-dwelling marine counterparts.

Bioturbation and Sedimentary Structures

Radiographic observations and dissections of sediments in the upper and central Chesapeake Bay and parallel investigations in the lower Bay indicate that the degree of bioturbation follows the salinity gradient, with the least amount of biological activity at the head and the greatest at the mouth of the estuary. Similar findings have been recorded in other estuarine systems (Winston and Anderson, 1971; Howard and Frey, 1975). The degree of bioturbation in the Bay is substantially reduced in the upper Bay because of active sedimentation. The predominance of physical structures over biological features in the deep-water channel regime is due to the presence of fluid muds and periodic anoxia. This conclusion is confirmed by sedimentary patterns and Pb^{210} data.

The stable mud environment is primarily inhabited by a sedentary tube and relatively permanent burrow-dwelling community. Irrigation of dwelling structures may result in the precipitation of various iron-rich substances as well as other compounds (rust-colored lining in sediments and halos in radiographs). Upon abandonment or death of the organism, most biogenic structures are back-filled with post-depositional surface material. However, some features remain open, serving as conduits for abiotic substances at depth. Similar sediment heterogeneity is known to produce complex chemical gradients in the Chesapeake Bay (Bricker and Troup, 1975) and elsewhere (Aller, 1977; Aller and Yingst, 1978).

Unlike the mud regime, sands are characterized by a more motile fauna. The random bioturbation of free-burrowing species has resulted in a more homogenous sediment texture. The mixing activities of the meiofauna have also been shown to be important in the general bioturbation of the sediment (Cullen, 1973). The homogenous fabric of sands suggests more uniform chemical gradients.

As faunal changes occur along the estuarine gradient, so does their influence on the substratum. The composition of the benthic community as well as the density of sediment-modifying species determines the extent of disturbance in the sediment (Dapples, 1949; Rhoads, 1967; McCall, et al., 1979). Based on Pb^{210} dating techniques, Goldhaber, et al. (1978) noted that sediment mixing rates extended from 5 cm in the upper Bay (western shore near Pooles Island) to 20 cm in the central Bay area (middle of the estuary across from the Little Choptank River) to 30 cm in the lower Bay (middle of the estuary just south of the Potomac River). In unstable areas (upper Bay or channels) physical and chemical activities (scouring by waves or tidal currents, molecular diffusion) result in the direct mixing and/or exchange of materials (solids and/or dissolved) within the sediments and across the sediment-water interface. In more stable areas of the Bay, organisms appear to be the major source of environmental variability. Mobile, deep-dwelling and deposit feeding species are generally more effective in processing the sediments than their sedentary, surface-dwelling and suspension feeding counterparts.

Depending on environmental conditions and population patterns, biologically-mediated effects on the sedimentary environment may be seasonally variable (Goldhaber, et al., 1977; Myers, 1977; Rhoads, et al., 1977). Because of the limited changes in sedimentation patterns in most areas of the Bay, time-dependent changes could not be observed in the radiographs but are reflected in the sediment chemistry. Generally, total community activity (bioturbation) increases during the summer. Chemical profiles during this time display strong chemical gradients. During the winter, the activities of the fauna decrease and chemical profiles have slopes indicating that molecular diffusion is more important than bioturbation. These changes have been noted in several areas of the Chesapeake Bay (Holdren and Bricker, 1977).

OVERVIEW and FUTURE RESEARCH CONSIDERATIONS

The distribution of the benthos and the examination of sedimentary structures in the upper and central regimes of the Chesapeake Bay have been examined in an effort to describe conditions active in the modification of the sedimentary environment. Physically dominated processes are found in the upper region of the estuary under an active sedimentation regime and in deep-water portions affected by fluid muds and periodic anoxia. Macrofaunal activities dominate most other areas of the Bay. The benthos are concentrated in the top 10 cm of the sediment, with less dense populations of adult and larger individuals occurring to 30 cm or more. The manner in which organisms alter the sediments has important geochemical and toxicant implications.

Based on species population patterns and the activity levels of Pb^{210} measured by Goldhaber, et al. (1977), the pooled data suggests that bioturbation of the sediment occurs in the top portion of the sediment column, being greatest at the sediment surface. Post-depositional downward mixing and back-filling of particulate materials can obscure the stratigraphic record. Upward transport of particles from the reduced to the oxidized environment will affect chemical diagenesis of the sediment (Aller, 1978). Penetration in the upper and central Bay was greatest in the mixed-sediment environments, primarily, and muds, secondarily. Toxicants are most concentrated in these regions. Sediment-absorbed toxicants in these sediment environments are likely to remain in the biologically active zone of 20-30 cm for up to 100 years.

Benthic organisms affect fluid as well as particulate transport. Intense reworking of the surface sediments and the establishment of dwelling structures result in an increased exchange of many dissolved constituents (Aller, 1977; McCaffrey, et al., 1980), including nutrients essential in the food web cycle (Rhoads, 1974; Nixon, et al., 1976). Little is known about the flux of toxicants, however.

Results of this biological investigation will serve as a baseline for present and future research. It is expected that our information will help to explain geochemical profiles and flux rates.

The natural environment is also subject to a great deal of temporal variability. The structure of the community may change seasonally or yearly but remain functionally the same over the long run. For instance, deep-dwelling, deposit-feeding species may be replaced by other deep-dwelling, deposit feeders between time periods, yet their effect on the sediment does not change. Quantitative information is required concerning individual species and their redistribution capabilities for model formulation. Such data is characteristically obtained by determining biological mixing rates under various environmental conditions (substrate, salinity, temperature). Once natural effects on the benthic community are ascertained, the influences of anthropogenic inputs can be more accurately assessed.

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Appendix I: Grain size distribution taken at vertical increments along box cores.

Station No.	Depth Interval (cm)	% Sand	% Silt	% Clay
1 (Fall 1978)	0-5	94.8	3.6	1.6
	5-10	30.0	48.9	21.1
	10-20	44.4	39.5	16.1
	20-30	45.5	38.5	16.0
	30-40	16.5	66.2	17.3
2 (Fall 1978)	0-5	44.0	40.4	15.6
	5-10	9.8	74.0	16.2
	10-15	8.2	66.3	25.5
	15-20	4.7	58.3	37.6
	20-25	8.7	58.8	32.5
	25-30	27.0	55.6	17.4
	30-35	10.6	60.2	29.2
	35-42	29.8	53.5	16.7
3 (Fall 1978)	0-5	9.3	47.4	43.3
	5-10	8.1	49.4	42.5
	10-20	10.2	47.9	41.9
	20-25	9.5	43.3	47.2
	25-30	8.2	44.5	47.3
	30-35	11.4	43.4	45.2
	35-40	12.6	41.2	46.2
	40-45	9.6	43.3	47.1
	45-50	8.3	46.2	45.5
	50-55.5	11.3	47.1	41.6
4 (Fall 1978)	0-5	10.4	59.6	30.0
	5-10	9.9	55.9	34.2
	10-15	7.0	62.1	30.9
	15-25	4.6	60.9	34.5
	25-30	10.3	48.2	41.5
	30-35	8.7	51.3	40.0
	35-52.5	8.8	50.3	40.9
5 (Fall 1978)	0-5	8.3	49.4	42.3
	5-10	10.4	55.0	34.6
	10-15	3.9	57.8	38.3
	15-20	3.9	58.4	37.7
	20-25	3.8	58.3	37.9
	25-30	4.4	59.5	36.1
	30-35	3.4	58.0	38.6
	35-40	2.8	59.7	37.5
	40-48	3.7	60.9	35.4

Appendix I: Grain size distribution (cont.)

Station No.	Depth Interval (cm)	% Sand	% Silt	% Clay
6 (Fall 1978)	0-5	4.4	34.2	61.4
	5-10	3.7	37.6	58.7
	10-15	1.9	35.4	62.7
	15-20	2.1	35.0	52.9
	20-25	1.4	33.7	64.9
	25-30	2.7	34.5	62.8
	30-35	6.4	31.3	62.3
	35-41	2.7	30.2	67.1
7 (Fall 1978)	0-5	2.3	32.8	64.9
	5-10	4.8	38.5	56.7
	10-15	3.1	36.1	60.8
	15-20	3.0	36.3	60.7
	20-25	2.0	36.2	61.8
	25-30	3.2	34.8	62.0
	30-35	5.5	33.1	61.4
	35-44	15.7	29.3	55.0
8 (Fall 1978)	0-5	0.4	34.2	65.4
	5-10	0.2	31.7	68.1
	10-15	0.0	37.8	62.2
	15-20	0.0	36.0	64.0
	20-25	0.1	46.4	53.5
	25-30	0.1	36.7	63.2
	30-40.5	0.2	38.4	61.4
9 (Fall 1978)	0-5	2.9	35.0	62.1
	5-10	3.3	36.1	60.6
	10-15	3.0	35.8	61.2
	15-20	3.0	33.1	63.9
	20-25	3.0	31.5	65.5
	25-30	3.0	32.0	65.0
	30-35	2.2	28.2	69.6
	35-40	1.4	29.0	69.6
	40-45	2.4	26.0	71.6
	45-49	1.7	27.8	70.5
10 (Fall 1978)	0-5	2.8	48.0	49.2
	5-10	7.3	46.0	46.7
	10-15	6.9	44.1	49.0
	15-20	3.7	42.9	53.4
	20-25	6.2	44.1	49.7
	25-30	0.0	39.6	60.4
	30-35	3.6	32.5	63.9
	35-44	2.4	31.4	66.2

Appendix I: Grain size distribution (cont.)

Station No.	Depth Interval (cm)	% Sand	% Silt	% Clay
11 (Fall 1978)	0-5	84.2	9.4	6.4
	5-10	-	-	-
	10-15	-	-	-
	15-20	81.7	9.5	8.8
	20-25	-	-	-
	25-35	-	-	-
12 (Fall 1978)	0-5	98.5	1.5	0.0
	5-10	98.3	1.7	0.0
13 (Fall 1978)	0-5	0.8	28.6	70.6
	5-10	0.7	29.5	69.8
	10-15	0.7	30.7	68.6
	15-25	1.1	30.4	68.5
	25-30	1.8	29.5	68.7
	30-38	3.6	29.2	67.2
14 (Fall 1978)	0-5	2.9	33.4	63.7
	5-10	0.2	29.7	70.1
	10-15	0.2	29.7	70.1
	15-25	1.3	29.5	69.2
	25-38	0.8	32.1	67.1
15 (Fall 1978)	0-5	21.4	61.5	17.1
	5-10	20.3	60.3	19.4
	10-15	22.2	58.3	19.5
	15-20	27.7	54.8	17.5
	20-25	22.0	54.7	23.3
	25-30	12.1	55.4	32.5
	30-35	6.2	56.1	37.7
	35-40	5.8	49.6	44.6
16 (Fall 1978)	0-5	15.8	56.2	28.0
	5-10	13.9	54.1	32.0
	10-15	12.7	52.3	35.0
	15-20	14.9	52.0	33.1
	20-25	14.8	50.5	34.7
	25-30	18.5	44.4	37.1
	30-35	14.2	48.4	37.4
	35-40	17.4	51.0	31.6

Appendix I: Grain size distribution (cont.)

Station No.	Depth Interval (cm)	% Sand	% Silt	% Clay
17 (Fall 1978)	0-5	19.4	49.3	31.3
	5-10	17.9	49.1	33.0
	10-15	18.7	46.0	35.3
	15-20	24.6	39.3	36.1
	20-25	16.4	46.8	36.8
	25-30	13.6	48.1	38.3
	30-35	12.4	47.5	40.1
	35-39	12.3	45.3	42.4
18 (Fall 1978)	0-5	0.8	32.9	66.3
	5-10	1.5	33.8	64.7
	10-15	1.4	36.2	62.4
	15-25	1.6	45.0	53.4
	25-33.5	4.0	47.7	48.3
19 (Fall 1978)	0-5	1.8	46.9	51.3
	5-10	1.7	47.5	50.8
	10-15	2.0	45.9	52.1
	15-20	8.6	41.6	49.8
	20-25	2.6	45.0	52.4
	25-30	2.0	44.3	53.7
	30-37.5	3.1	42.8	54.1
20 (Fall 1978)	0-5	92.9	7.1	0.0
	5-10	86.9	13.1	0.0
	15-20	85.7	8.1	6.2
	20-31	83.5	9.7	6.8
22 (Fall 1978)	0-5	43.1	32.7	24.2
	5-10	55.8	26.5	17.7
	10-15	24.8	43.6	31.6
	15-20	20.8	46.3	32.9
	20-25	18.5	47.4	34.1
	25-30	4.4	54.6	41.0
	30-35	2.6	54.8	42.6
	35-40.5	7.0	50.1	42.9
23 (Fall 1978)	0-5	4.3	40.1	56.6
	5-10	4.4	48.3	47.3
	10-15	3.0	45.5	51.5
	15-20	2.4	47.2	50.4
	20-25	2.8	46.9	50.3
	25-30	3.7	47.9	48.4
	30-35	4.6	49.3	46.1
	35-39	5.3	49.7	45.0

Appendix I: Grain size distribution (cont.)

Station No.	Depth Interval (cm)	% Sand	% Silt	% Clay
24 (Fall 1978)	0-5	2.5	51.5	46.0
	5-10	2.8	55.2	42.0
	10-20	3.8	52.4	43.8
	20-40	2.7	56.7	40.6
25 (Fall 1978)	0-5	98.7	1.3	0.0
	5-10	99.3	0.7	0.0
	10-15	99.4	0.6	0.0
1 (Summer 1979)	0-2	79.9	10.4	9.6
	2-5	99.6	0.4	0.0
	5-10	99.5	0.5	0.0
	10-15	99.6	0.4	0.0
	15-20	99.6	0.4	0.0
	20-30	99.7	0.3	0.0
	30-40	99.6	0.4	0.0
2 (Summer 1979)	0-2	18.5	53.0	28.5
	2-5	18.3	52.3	29.4
	5-10	18.7	57.2	24.1
	10-15	7.6	62.3	30.1
	15-20	6.0	64.6	29.4
	20-30	3.8	61.8	34.4
	30-40	3.2	63.0	33.8
	40-50	11.5	58.4	30.1
6 (Summer 1979)	0-2	3.2	35.4	61.4
	2-5	2.5	36.7	60.7
	5-10	1.0	38.1	60.9
	10-15	1.2	37.0	61.8
	15-20	0.8	35.5	63.7
	20-30	1.0	36.0	63.0
	30-40	2.4	27.3	70.3
	40-56	7.1	32.4	60.5
7 (Summer 1979)	0-2	14.9	33.3	51.8
	2-5	27.1	28.8	44.1
	5-10	30.6	28.7	40.7
	10-15	29.3	35.3	35.4
	15-20	31.5	38.5	30.0
	20-30	18.1	58.2	23.7
	30-40	23.9	55.9	20.2
	40-47	35.2	47.0	17.8

Appendix I: Grain size distribution (cont.)

Station No.	Depth Interval (cm)	% Sand	% Silt	% Clay
8 (Summer 1979)	0-2	0.7	36.6	62.7
	2-5	0.6	37.6	61.8
	5-10	0.3	34.8	64.9
	10-20	5.0	35.7	59.3
	20-30	0.4	43.7	55.9
	30-40	0.3	34.4	65.3
13 (Summer 1979)	0-2	0.8	28.4	70.8
	2-5	1.0	30.0	69.0
	5-10	1.7	32.4	65.9
	10-15	1.1	31.6	67.4
	15-20	1.0	32.4	66.6
	20-30	1.3	32.0	66.7
	30-40	1.6	31.7	66.7
	40-50	1.8	35.5	62.7
14 (Summer 1979)	0-2	3.5	31.0	65.6
	2-5	2.7	29.3	68.0
	5-10	2.4	24.6	73.0
	10-15	1.0	29.0	70.0
	15-20	0.4	25.3	74.3
	20-30	0.7	26.6	72.7
	30-40	0.6	27.1	72.3
	40-54	0.6	29.2	70.2
15 (Summer 1979)	0-2	21.0	59.4	19.6
	2-5	20.6	57.8	21.6
	5-10	14.9	61.3	23.8
	10-15	14.7	61.5	23.8
	15-20	18.0	56.9	25.1
	20-30	15.2	59.8	25.0
	30-40	7.5	59.4	33.1
	40-48	4.6	53.6	41.8
21 (Summer 1979)	0-2	15.7	58.8	25.5
	2-5	17.1	57.2	25.8
	5-10	23.6	50.0	26.4
	10-15	28.4	46.3	25.3
	15-20	25.8	49.7	24.5
	20-30	15.7	54.2	30.1
	30-36	13.2	56.6	30.2

Appendix I: Grain size distribution (cont.)

Station No.	Depth Interval (cm)	% Sand	% Silt	% Clay
23 (Summer 1979)	0-2	5.1	44.9	50.0
	2-5	5.4	45.1	49.5
	5-10	3.2	43.0	53.8
	10-15	4.3	45.2	50.5
	15-20	3.2	44.6	52.2
	20-30	3.1	43.5	53.3
	30-37	4.4	45.9	49.7
24 (Summer 1979)	0-2	0.9	46.5	52.5
	2-5	2.3	50.8	46.9
	5-10	0.4	42.0	57.6
	10-15	3.4	44.8	51.8
	15-20	1.9	45.4	52.7
	20-30	-	-	-
	30-41	5.8	43.4	50.8
25 (Summer 1979)	0-2	86.4	6.0	7.5
	2-5	-	-	-
	5-10	95.6	4.4	0.0
	10-16	99.0	1.0	0.0
51 (Summer 1979)	0-2	98.9	3.7	2.4
	2-5	98.0	2.0	0.0
	5-10	3.9	65.6	30.5
	10-15	1.8	66.8	31.4
	15-20	1.3	60.2	38.5
	20-33	2.0	53.1	44.9
52 (Summer 1979)	0-2	56.0	32.9	11.1
	2-5	51.2	36.1	12.7
	5-10	57.8	31.5	10.7
	10-15	28.5	47.4	24.1
	15-20	3.9	64.5	31.6
	20-30	2.6	58.7	38.6
	30-40	0.3	53.9	45.8
	40-50	1.8	60.0	38.2
53 (Summer 1979)	0-2	15.2	48.7	36.1
	2-5	15.7	51.4	32 9
	5-10	1.1	53.8	45.1
	10-15	0.4	54.9	44.7
	15-20	2.0	54.7	43.3
	20-30	15.9	45.7	38.4
	30-40	1.8	51.3	46.9
	40-50	0.4	53.0	46.6

Appendix I: Grain size distribution (cont.)

Station No.	Depth Interval (cm)	% Sand	% Silt	% Clay
54 (Summer 1979)	0-2	9.8	38.7	51.5
	2-5	8.5	36.7	54.7
	5-10	9.2	34.8	56.0
	10-15	9.3	31.9	58.8
	15-20	6.2	31.5	62.3
	20-30	9.0	32.8	58.2
	30-40	16.3	30.4	53.3
	40-48	9.6	32.1	58.3
55 (Summer 1979)	0-5	1.0	33.9	65.0
	5-10	2.0	38.9	59.1
	10-15	1.1	32.0	66.9
	15-20	0.5	35.1	64.4
	20-30	0.6	34.8	64.5
	30-40	-	-	-
	40-50	-	-	-
	50-60	-	-	-
56 (Summer 1979)	0-2	58.9	21.2	19.9
	2-5	74.4	13.4	12.2
	5-10	76.9	10.5	12.5
	10-15	88.8	4.9	6.3
	15-20	92.3	3.5	4.2
	20-33	89.5	4.7	6.4
57 (Summer 1979)	0-2	2.0	38.0	60.0
	2-5	2.0	37.7	60.3
	5-10	1.3	37.3	61.4
	10-15	1.3	37.3	61.4
	15-20	2.1	38.5	59.4
	20-30	3.6	39.8	56.6
	30-40	1.3	30.0	68.7
	40-52	-	-	-
58 (Summer 1979)	0-2	4.2	39.7	56.1
	2-5	3.8	41.3	54.9
	5-10	6.1	40.2	53.7
	10-15	0.8	45.0	54.2
	15-20	2.3	33.1	64.6
	20-30	0.8	34.6	64.6
	30-40	0.9	33.3	65.8
	40-48	1.0	30.7	68.2

Appendix I: Grain size distribution (cont.)

Station No.	Depth Interval (cm)	% Sand	% Silt	% Clay
59 (Summer 1979)	0-2	98.6	1.4	0.0
	2-5	99.4	0.2	0.0
	5-10	99.3	0.7	0.0
	10-15	100.0	0.0	0.0
	15-18	100.0	0.0	0.0
60 (Summer 1979)	0-2	2.4	37.1	60.5
	2-5	3.4	37.2	59.4
	5-10	5.2	40.7	54.2
	10-15	1.0	34.7	64.3
	15-20	6.0	37.0	57.0
	20-30	7.0	37.0	56.0
	30-40	12.2	36.4	51.4
	40-50	8.1	39.8	52.1
61 (Summer 1979)	0-2	14.5	32.1	53.4
	2-5	26.7	30.1	43.2
	5-10	37.0	25.8	37.2
	10-15	53.1	19.5	27.4
	15-20	57.0	18.5	24.5
	20-30	53.8	20.2	26.0
	30-40	62.0	17.4	20.6
62 (Summer 1979)	0-2	1.2	40.9	57.9
	2-5	3.1	46.2	50.7
	5-10	1.8	39.0	59.2
	10-15	1.8	40.0	58.2
	15-20	2.2	44.0	53.8
	20-30	1.7	42.2	56.1
	30-40	1.3	41.6	57.2
63 (Summer 1979)	0-2	12.4	45.9	41.6
	2-5	14.6	60.2	25.1
	5-10	19.8	58.9	21.3
	10-15	22.5	57.8	19.7
	15-20	23.1	55.5	21.4
	20-30	18.9	58.1	23.0
	30-40	25.8	50.7	23.5
	40-48	31.5	46.2	22.3

Appendix I: Grain size distribution (cont.)

Station No.	Depth Interval (cm)	% Sand	% Silt	% Clay
64 (Summer 1979)	0-2	4.7	59.5	35.8
	2-5	4.2	59.2	36.6
	5-10	4.7	51.7	43.6
	10-15	2.5	54.1	43.4
	15-20	1.5	49.8	48.7
	20-30	2.4	50.8	46.8
	30-35	4.5	54.0	41.5
65 (Summer 1979)	0-2	90.2	5.3	4.5
	2-5	90.7	4.8	4.5
	5-10	88.1	5.9	6.0
	10-15	-	-	-
	15-20	89.8	5.1	5.1
	20-37	91.4	3.9	4.7

Note: Dashes (-) refer to missing data.

Appendix II. Macrobenthic species collected in upper and central Chesapeake Bay, Fall 1978 and Summer 1979.

- PHYLUM PLATYHELMINTHES
    - Family Stylochidae
        - _Stylochus ellipticus_
- PHYLUM RHYNCHOCOELA
    - Family Lineidae
        - *_Cerebratulus lacteus_
        - *Nemertean sp.
- PHYLUM ANNELIDA
    - Class Polychaeta
        - Family Ampharetidae
            - _Amphicteus floridans_
        - Family Amphictenidae
            - *_Pectinaria gouldii_
        - Family Amphinomidae
            - *_Pseudeurythoe ambigua_
        - Family Capitellidae
            - *_Heteromastus filiformis_
        - Family Cirratulidae
            - _Tharyx setigera_
        - Family Glyceridae
            - *_Glycera dibranchiata_
        - Family Goniadidae
            - *_Glycinde solitaria_
        - Family Nereidae
            - *_Nereis succinea_
        - Family Orbiniidae
            - *_Scoloplos fragilis_
            - _Scoloplos rubra_
        - Family Phyllodocidae
            - *_Eteone heteropoda_
        - Family Spionidae
            - *_Paraprionspio pinnata_
            - _Polydora ligni_
            - *_Scolecolepides viridis_
            - *_Streblospio benedicti_
        - Family Terebellidae
            - _Loimia medusa_
    - Class Oligochaeta
        - Family Tubificidae
            - *Oligochaete spp.
- PHYLUM MOLLUSCA
    - Class Bivalvia
        - Family Corbiculidae
            - *_Corbicula manilensis_
        - Family Lucinacea
            - _Lucina multilineata_
        - Family Lyonsiidae
            - *_Lyonsia hyalina_
        - Family Mactridae
            - *_Mulinia lateralis_
            - *_Rangia cuneata_

Appendix II. Macrobenthis species collected (cont.)

- PHYLUM MOLLUSCA
  - Class Bivalvia
    - Family Myacidae
      - *Mya arenaria
    - Family Sphaeriidae
      - *Pisidium sp.
    - Family Tellinidae
      - *Macoma balthica
      - *Macoma mitchelli
    - Family Veneridae
      - Mercenaria campechiensis
  - Class Gastropoda
    - Family Corambidae
      - *Doridella obscura
    - Family Retusidae
      - *Retusa canaliculata
- PHYLUM ARTHROPODA
  - Class Crustacea
    - Order Amphipoda
      - Family Ampeliscidae
        - *Ampelisca abdita
        - Ampelisca vadorum
      - Family Corophiidae
        - *Corophium lacustre
      - Family Gammaridae
        - *Gammarus mucronatus
      - Family Photidae
        - *Leptocheirus plumulosus
    - Order Cumacea
      - Family Bodotriidae
        - *Cyclaspis varians
    - Order Decapoda
      - Family Xanthidae
        - *Rhithropanopeus harrisii
    - Order Isopoda
      - Family Anthuridae
        - *Cyathura polita
      - Family Idoteidae
        - *Chirodotea caeca
    - Order Mysidacea
      - Family Mysidae
        - *Neomysis americana
  - Class Insecta
    - Family Tendipidae (=Chrionomidae)
      - *Chironomus sp.
      - *Clinotanypus sp.
      - *Coelotanypus sp.
      - *Cryptochironomus sp.
      - *Procladius sp.
- PHYLUM PHORONIDA
  - Phoronis sp.

*Species found in the upper (oligobaline) and central (mesohaline) regimes.

Appendix III. Species, abundance and biomass for each station, Fall 1978 and Summer 1979.

Station 1

(9/27/78)

	Depth Interval (cm)			
	0-5		5-10	
	#	B (mg)	#	B (mg)
Oligochaetea				
Oligochaete sp.	91	4.5	9	0.6
Molluscs				
Corbicula manilensis	2	0.8	-	-
Insects				
Chironomus sp.	4	4.6	3	4.2
Clinotanypus sp.	6	0.7	-	-

Station 2

(9/28/78)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Oligochaetes						
Oligochaete sp.	20	0.6	86	2.9	77	2.6
Polychaetes						
Scolecolepides viridis	2	6.1	4	17.9	3	11.8
Molluscs						
Doridella obscura	1	0.2	-	-	-	-
Pisidium sp.	2	0.9	-	-	-	-
Crustaceans						
Chirodotea caeca	2	0.3	-	-	-	-
Cyathura polita	1	0.2	1	5.3	-	-
Leptocheirus plumulosus	14	4.2	-	-	-	-
Insects						
Chironomus sp.	1	0.2	-	-	-	-

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Station 3

(9/27/78)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Polychaetes						
Scolecolepides viridis	2	6.6	3	11.4	1	4.1
Molluscs						
Mulinia lateralis	2	3.3	-	-	-	-
Crustaceans						
Chirodotea caeca	1	0.2	-	-	-	-
Cyathura polita	1	0.3	2	11.2	-	-
Leptocheirus plumulosus	16	4.1	1	0.3	-	-
Insects						
Clinotanypus sp.	5	0.7	3	0.5	1	0.2

Station 4

(9/26/78)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans						
Cerebratulus lacteus	-	-	-	-	1	2.1
Oligochaetes						
Oligochaete sp.	1	N	2	0.1	6	0.2
Polychaetes						
Scolecolepides viridis	10	21.7	13	37.5	-	-
Molluscs						
Mulinia lateralis	2	5.3	-	-	-	-
Crustaceans						
Cyathura polita	1	0.9	2	4.2	-	-
Leptocheirus plumulosus	153	36.7	6	1.6	-	-

Station 5

(9/28/79)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Oligochaetes						
Oligochaete sp.	1	N	-	-	-	-
Polychaetes						
Scolecolepides viridis	5	7.2	6	22.4	4	19.4
Crustaceans						
Cyathura polita	3	3.0	1	1.3	-	-
Leptocheirus plumulosus	101	21.9	9	2.9	-	-
Insects						
Clinotanypus sp.	1	0.1	-	-	-	-

Station 6

(9/26/78)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Oligochaetes						
Oligochaete sp.	-	-	2	0.1	2	0.1
Polychaetes						
Heteromastus filiformis	2	0.5	3	1.4	2	2.0
Nereis succinea	9	36.9	2	11.3	-	-
Molluscs						
Macoma balthica	1	6.1	1	68.4	8	849.2
Macoma mitchelli	1	2.3	1	1.9	-	-
Crustaceans						
Leptocheirus plumulosus	57	15.5	2	0.6	-	-
Rithropanopeus harissi	1	37.7	-	-	-	-

TYPING GUIDE SHEET

Station 7

(10/2/78)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans						
Cerebratulus lacteus	1	0.8	-	-	4	4.1
Oligochaetes						
Oligochaete sp.	3	0.1	1	N	-	-
Polychaetes						
Heteromastus filiformis	2	0.4	3	1.3	2	1.7
Nereis succinea	5	6.0	-	-	-	-
Streblospio benedicti	1	0.1	-	-	-	-
Molluscs						
Macoma balthica	2	16.6	11	353.5	6	594.0
Macoma mitchelli	3	6.2	-	-	-	-
Crustaceans						
Cyathura polita	3	15.3	2	33.0	-	-
Leptocheirus plumulosus	51	13.1	2	0.5	-	-

TYPING GUIDE SHEET

Station 8

(9/29/78)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Oligochaetes						
Oligochaete sp.	3	0.1	36	1.1	5	0.2
Polychaetes						
Paraprionspio pinnata	2	0.8	2	2.0	-	-
Streblospio benedicti	24	2.3	-	-	-	-
Molluscs						
Macoma balthica	-	-	1	57.1	-	-
Crustaceans						
Leptocheirus plumulosus	1	0.2	-	-	-	-

Station 9

(9/28/78)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans						
Cerebratulus lacteus	-	-	-	-	3	2.7
Oligochaetes						
Oligochaete sp.	2	0.1	7	0.3	1	N
Polychaetes						
Nereis succinea	2	13.7	3	21.3	-	-
Paraprionspio pinnata	1	1.0	-	-	-	-
Streblospio benedicti	19	1.6	-	-	-	-
Molluscs						
Macoma balthica	1	1.8	4	10.4	-	-
Macoma mitchelli	1	0.7	-	-	-	-
Crustaceans						
Gammarus mucronatus	6	1.8	-	-	-	-
Leptocheirus plumulosus	1	0.2	1	0.3	-	-

Station 10

(10/2/78)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Oligochaetes						
Oligochaete sp.	1	N	5	0.2	-	-
Polychaetes						
Heteromastus filiformis	-	-	2	0.9	-	-
Nereis succinea	2	0.8	-	-	-	-
Streblospio benedicti	104	10.8	2	0.1	-	-
Molluscs						
Macoma balthica	-	-	1	21.2	3	137.7
Crustaceans						
Gammarus mucronatus	1	0.2	-	-	-	-

Station 11

(10/3/78)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Nerteans						
Cerebratulus lacteus	2	0.5	-	-	-	-
Polychaetes						
Heteromastus filiformis	1	0.4	2	1.2	-	-
Nereis succinea	4	5.9	-	-	-	-
Paraprionspio pinnata	1	0.9	-	-	-	-
Streblospio benedicti	16	1.5	-	-	-	-
Molluscs						
Macoma balthica	2	43.5	6	143.8	1	28.8

Station 12

(10/3/78)

	Depth Interval (cm)			
	0-5		5-10	
	#	B (mg)	#	B (mg)
Nemerteans				
Cerebratulus lacteus	4	2.5	1	1.0
Polychaetes				
Heteromastus filiformis	2	0.4	10	3.1
Paraprionspio pinnata	3	2.5	-	-
Streblospio benedicti	21	2.0	-	-
Molluscs				
Macoma balthica	1	5.2	1	9.9
Macoma mitchelli	2	12.3	-	-

Station 13

(11/7/78)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Polychaetes						
Glycinde solitaria	2	2.3	-	-	-	-
Nereis succinea	3	6.3	11	102.5	2	14.5
Paraprionspio pinnata	2	2.4	13	41.9	1	1.6
Streblospio benedicti	27	2.6	-	-	-	-
Molluscs						
Macoma mitchelli	-	-	1	6.1	-	-

Station 14

(11/7/78)

	Depth Interval (cm)			
	0-5		5-10	
	#	B (mg)	#	B (mg)
Oligochaetes				
Oligochaete sp.	2	0.1	-	-
Polychaetes				
Nereis succinea	1	1.7	1	3.9
Paraprionspio pinnata	33	16.5	6	3.7
Streblospio benedicti	4	0.4	-	-

Station 15

(11/8/78)

	Depth Interval (cm)							
	0-5		5-10		10-20		20-30	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
OLigochaetes								
Oligochaete sp.	17	0.6	6	0.2	2	0.1	-	-
Polychaetes								
Glycera dibranchiata	-	-	1	2.7	-	-	-	-
Glycinde solitaria	3	6.4	-	-	-	-	-	-
Heteromastus filiformis	9	3.1	8	5.2	6	6.9	-	-
Nereis succinea	5	14.4	2	21.9	5	151.2	2	43.8
Scolecolepides viridis	8	41.8	2	16.3	-	-	-	-
Scoloplos fragilis	1	4.1	-	-	-	-	-	-
Streblospio benedicti	41	4.3	-	-	-	-	-	-
Molluscs								
Macoma balthica	5	33.9	13	160.7	18	2504.8	5	536.0
Macoma mitchelli	5	13.0	-	-	1	10.2	-	-
Crustaceans								
Cyathura polita	2	1.7	-	-	-	-	-	-
Leptocheirus plumulosus	105	31.1	15	3.7	-	-	-	-

Station 16

(11/7/78)

	Depth Interval (cm)							
	0-5		5-10		10-20		20-30	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans								
Cerebratulua lacteus	1	2.2	-	-	-	-	-	-
Oligochaetes								
Oligochaete sp.	-	-	1	N	-	-	-	-
Polychaetes								
Glycinde solitaria	2	3.6	-	-	-	-	-	-
Heteromastus filiformis	5	1.5	5	2.9	13	18.4	-	-
Nereis succinea	6	24.7	-	-	1	9.1	1	4.6
Scolecolepides viridis	1	4.7	-	-	-	-	-	-
Streblospio benedicti	31	4.1	-	-	-	-	-	-
Molluscs								
Macoma balthica	16	614.9	22	2371.0	3	342.0	-	-
Macoma mitchelli	2	11.1	-	-	-	-	-	-
Crustaceans								
Leptocheirus plumulosus	161	45.9	19	5.7	-	-	-	-

Station 17

(11/6/78)

	Depth Interval (cm)							
	0-5		5-10		10-20		20-30	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Oligochaetes								
Oligochaete sp.	4	0.1	-	-	-	-	-	-
Polychaetes								
Glycinde solitaria	5	3.2	-	-	-	-	-	-
Heteromastus filiformis	1	0.4	2	0.9	8	13.9	2	3.6
Nereis succinea	9	53.9	9	107.6	3	46.7	-	-
Paraprionspio pinnata	2	4.0	3	8.9	2	5.5	-	-
Scolecolepides viridis	1	8.7	2	16.9	-	-	-	-
Streblospio benedicti	13	1.6	-	-	-	-	-	-
Molluscs								
Macoma balthica	-	-	4	94.9	5	171.2	2	120.3
Macoma mitchelli	4	1.3	2	22.1	-	-	-	-
Crustaceans								
Leptocheirus plumulosus	5	1.3	-	-	-	-	-	-

Station 18

(11/6/78)

	Depth Interval (cm)	
	0-5	
	##	B (mg)
Polychaetes		
Paraprionspio pinnata	2	3.8
Streblospio benedicti	6	0.7

Station 19

(11/5/78)

	Depth Interval (cm)	
	0-5	
	#	B (mg)
Polychaetes		
Nereis succinea	1	2.6
Paraprionspio pinnata	36	17.6
Streblospio benedicti	3	0.3

Station 20

(11/3/78)

	Depth Interval (cm)			
	0-5		5-10	
	#	B (mg)	#	B (mg)
Oligochaetes				
Oligochaete sp.	37	1.2	1	N
Polychaetes				
Glycera dibranchiata	5	25.4	-	-
Glycinde solitaria	1	1.0	-	-
Heteromastus filiformis	13	9.7	3	2.1
Nereis succinea	3	18.3	-	-
Paraprionspio pinnata	1	3.1	-	-
Pectinaria gouldii	4	110.4	-	-
Scolecolepides viridis	2	8.1	-	-
Scoloplos rubra	1	6.2	-	-
Streblospio benedicti	2	0.2	-	-
Tharyx setigera	1	1.0	-	-

Station 21

(11/2/78)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans						
Cerebratulus lacteus	-	-	1	2.4	-	-
Oligochaetes						
Oligochaete sp.	2	0.1	-	-	-	-
Polychaetes						
Glycera dibranchiata	-	-	-	-	1	98.9
Glycinde solitaria	3	5.8	-	-	-	-
Paraprionspio pinnata	50	123.0	2	5.1	-	-
Tharyx setigera	1	1.0	-	-	-	-
Crustaceans						
Ampelisca vadorum	8	1.9	-	-	-	-
Neomysis americana	2	3.1	-	-	-	-

Station 22

(11/2/78)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Polychaetes						
Paraprionspio pinnata	21	72.1	3	9.8	2	6.9
Streblospio benedicti	1	0.1	-	-	-	-

Station 23

(11/4/78)

	Depth Interval (cm)			
	0-5		5-10	
	#	B (mg)	#	B (mg)
Polychaetes				
Nereis succinea	3	10.3	2	8.6
Paraprionspio pinnata	15	23.9	-	-
Molluscs				
Mulinia lateralis	1	8.6	-	-

Station 24

(11/5/78)

	Depth Interval (cm)			
	0-5		5-10	
	#	B (mg)	#	B (mg)
Polychaetes				
Glycinde solitaria	1	1.5	-	-
Nereis succinea	4	15.0	1	6.1
Paraprionspio pinnata	230	285.2	4	4.7
Pectinaria gouldii	2	6.0	-	-
Crusteceans				
Ampelisca abdita	1	0.2	-	-

Station 25
(11/3/78)

	Depth Interval (cm)					
	0-5		5-10		10-20	
	#	B (mg)	#	B (mg)	#	B (mg)
Polychaetes						
Glycera dibranchiata	1	3.2	-	-	1	73.8
Glycinde solitaria	2	2.1	-	-	-	-
Heteromastus filiformis	-	-	1	0.3	-	-
Loimia medusa	1	3.4	-	-	-	-
Paraprionspio pinnata	26	80.6	1	2.6	2	4.6
Pectinaria gouldii	1	0.9	-	-	-	-
Pseudeurythoe ambigua	1	3.7	-	-	-	-
Scoloplos rubra	2	10.4	2	14.2	3	35.8
Molluscs						
Lucina multilineata	1	2.5	-	-	-	-
Mulinea lateralis	1	24.5	-	-	-	-
Retusa canaliculata	5	1.0	-	-	-	-
Crustaceans						
Ampelisca vadorum	3	0.7	-	-	-	-
Phoronids						
Phoronis sp.	1	2.8	3	10.8	9	30.6

Station 1

(7/5/79)

	Depth Interval (cm)					
	0-2		2-5		5-10	
	#	B (mg)	#	B (mg)	#	B (mg)
Oligochaetes						
Oligochaete sp.	-	-	-	-	4	0.2
Insects						
Chironomus sp.	8	1.6	4	0.8	-	-
Cryptochironumus sp.	2	0.2	-	-	-	-

Station 2

(7/4/79)

Depth Interval (cm)

	0-2		2-5		5-10		10-15		15-20		20-30	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Oligochaetes												
Oligochaete sp.	3	0.1	1	0.1	2	0.1	9	0.4	8	0.4	10	0.5
Polychaetes	7	30.8	6	27.9								
Scolecolepides viridis	7	30.8	6	27.9	3	13.8	3	14.1	1	4.0	-	-
Molluscs	2	0.2										
Pisidium sp.	2	0.2	-	-	-	-	-	-	-	-	-	-
Crustaceans	2	0.6										
Chirodotea caeca	2	0.6	-	-	-	-	-	-	-	-	-	-
Leptocheirus plumulosus	1	0.2	2	0.3	-	-	-	-	-	-	-	-
Insects												
Clinotanypus sp.	1	0.1	-	-	-	-	-	-	-	-	-	-

Station 6

(7/3/79)

	Depth Interval (cm)													
	0-2		2-5		5-10		10-15		15-20		20-30		30-40	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans														
Nemertean sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligochaetes														
Oligochaete sp.	2	0.1	6	0.3	-	-	-	-	-	-	-	-	-	-
Polychaetes														
Heteromastus filiformis	-	-	-	-	-	-	1	0.4	1	0.4	4	1.9	4	5.7
Nereis succinea	9	18.6	9	12.1	2	23.3	2	43.9	-	-	-	-	-	-
Scolecolepides viridis	1	0.5	4	2.6	-	-	-	-	-	-	-	-	-	-
Molluscs														
Macoma balthica	-	-	1	3.0	-	-	9	1097.5	1	433.8	-	-	-	-
Rangia cuneata	2	1.7	-	-	-	-	-	-	-	-	-	-	-	-
Crustaceans														
Cyathura polita	4	0.4	3	34.6	-	-	-	-	-	-	-	-	-	-
Leptocheirus plumulosis	165	66.0	54	22.1	10	4.6	-	-	-	-	-	-	-	-

Station 7

(7/3/79)

	Depth Interval (cm)													
	0-2		2-5		5-10		10-15		15-20		20-30		30-40	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans														
Nemertean sp.	-	-	-	-	-	-	2	1.0	-	-	-	-	-	-
Oligochaetes														
Oligochaete sp.	10	0.5	5	0.3	-	-	-	-	-	-	-	-	-	-
Polychaetes														
Heteromastus filiformis	-	-	1	0.2	3	0.8	2	0.8	4	0.8	1	0.2	1	0.3
Nereis succinea	8	12.2	10	71.6	2	10.0	-	-	-	-	-	-	-	-
Molluscs														
Macoma balthica	10	7.9	2	5.7	5	630.7	2	337.2	-	-	1	139.8	-	-
Mulinia lateralis	-	-	1	0.3	-	-	-	-	-	-	-	-	-	-
Crustaceans														
Corophium lacustre	11	1.1	-	-	-	-	-	-	-	-	-	-	-	-
Cyathura polita	4	0.4	2	2.0	3	13.8	-	-	-	-	-	-	-	-
Leptocheirus plumulosus	287	176.2	44	27.9	16	9.3	-	-	-	-	-	-	-	-

Station 8

(7/3/79)

	Depth Interval (cm)									
	0-2		2-5		5-10		10-15		15-18	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans										
Nemertean sp.	-	-	-	-	1	6.5	-	-	1	37.9
Oligochaetes										
Oligochaete sp.	-	-	5	0.3	17	0.9	-	-	-	-
Polychaetes										
Nereis succinea	-	-	1	4.9	-	-	2	54.6	1	27.0
Scolecolepides viridis	6	103.2	4	70.8	4	69.5	-	-	-	-
Streblospio benedicti	5	0.5	-	-	-	-	-	-	-	-
Molluscs										
Macoma balthica	2	16.2	8	80.9	3	33.8	-	-	-	-
Macoma mitchelli	-	-	-	-	1	23.0	-	-	-	-
Crustaceans										
Leptocheirus plumulosus	170	11.0	30	2.9	14	1.6	-	-	-	-

Station 13

(7/11/79)

	Depth Interval (cm)											
	0-2		2-5		5-10		10-15		15-20		20-30	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans												
Nemertean sp.	4	0.5	-	-	-	-	-	-	-	-	-	-
Oligochaetes												
Oligochaete sp.	2	0.1	-	-	-	-	-	-	-	-	-	-
Polychaetes												
Eteone heteropoda	2	0.8	1	0.9	-	-	-	-	-	-	-	-
Heteromastus filiformis	3	0.4	5	1.0	4	0.9	2	0.5	2	0.5	1	0.2
Nereis succinea	-	-	-	-	-	-	-	-	1	45.8	1	46.5
Scolecolepides viridis	3	49.4	16	270.2	17	291.4	-	-	-	-	-	-
Streblospio benedicti	6	0.6	-	-	-	-	-	-	-	-	-	-
Molluscs												
Macoma balthica	14	92.5	4	61.3	2	138.0	-	-	-	-	-	-
Macoma mitchelli	6	65.7	2	203.4	1	65.5	-	-	-	-	-	-
Crustaceans												
Leptocheirus plumulosus	7	0.8	-	-	-	-	-	-	-	-	-	-

Station 14

(6/30/79)

	Depth Interval (cm)							
	0-2		2-5		5-10		10-15	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Oligochaetes								
Oligochaete sp.	9	0.5	2	0.1	-	-	-	-
Polychaetes								
Eteone heteropoda	-	-	1	0.4	1	1.2	-	-
Nereis succinea	2	0.3	2	0.1	-	-	1	9.9
Paraprionspio pinnata	-	-	1	1.0	1	1.3	1	1.2
Scolecolepides viridis	-	-	1	1.9	-	-	-	-
Streblospio benedicti	83	8.0	12	1.2	-	-	-	-
Molluscs								
Macoma balthica	13	12.1	14	41.7	1	21.7	-	-
Macoma mitchelli	-	-	2	5.0	-	-	-	-
Mulinia lateralis	4	9.3	1	1.0	-	-	-	-

Station 15

(6/30/79)

	Depth Interval (cm)													
	0-2		2-5		5-10		10-15		15-20		20-30		30-40	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans														
Nemertean sp.	7	1.8	6	2.5	2	0.3	-	-	-	-	-	-	-	-
Oligochaetes														
Oligochaete sp.	8	0.4	50	2.5	14	0.7	6	0.3	10	0.5	-	-	-	-
Polychaetes														
Heteromastus filiformis	3	0.6	38	9.0	57	18.3	29	9.7	19	4.1	3	0.9	1	0.4
Nereis succinea	7	7.4	4	25.3	4	165.9	2	59.4	-	-	-	-	-	-
Paraprionspio pinnata	-	-	-	-	1	0.4	-	-	-	-	-	-	-	-
Scolecolepides viridis	2	34.4	5	86.5	-	-	-	-	-	-	-	-	-	-
Streblospio benedicti	37	3.4	3	0.3	-	-	-	-	-	-	-	-	-	-
Molluscs														
Macoma balthica	10	6.6	6	105.9	8	62.0	8	953.0	12	1693.8	16	2057.3	-	-
Macoma mitchelli	-	-	2	55.1	-	-	-	-	-	-	-	-	-	-
Crustaceans														
Leptocheirus plumulosus	5	1.0	-	-	1	0.1	-	-	-	-	-	-	-	-

Station 21

(6/26/79)

	Depth Interval (cm)									
	0-2		2-5		5-10		10-15		15-20	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans										
Nemertean sp.	-	-	-	-	-	-	3	14.5	-	-
Oligochaetes										
Oligochaete sp.	3	0.1	-	-	-	-	-	-	-	-
Polychaetes										
Eteone heterpoda	8	3.1	1	0.5	-	-	-	-	-	-
Glycera dibranchiata	-	-	1	1.2	-	-	-	-	-	-
Glycinde solitaria	3	4.2	-	-	-	-	-	-	-	-
Heteromastus filiformis	4	0.8	1	0.2	0	0	4	18.8	-	-
Nereis succinea	-	-	-	-	-	-	-	-	1	17.3
Paraprionspio pinnata	1	2.5	4	13.2	2	9.0	-	-	-	-
Streblospio benedicti	37	3.7	-	-	-	-	-	-	-	-
Molluscs										
Lyonsia hyalina	1	0.1	-	-	-	-	-	-	-	-
Macoma balthica	-	-	-	-	14	86.2	18	243.3	2	28.0

Station 21 (cont.)

(6/26/79)

Depth Interval (cm)

	0-2		2-5		5-10		10-15		15-20	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Molluscs (cont.)										
Macoma _mithcelli_	-	-	6	11.5	1	31.6	1	24.3	-	-
Mulinia _lateralis_	23	4.0	2	0.8	-	-	-	-	-	-
Crustaceans										
Ampelisca _abdita_	1	0.2	-	-	-	-	-	-	-	-

Station 23

(6/26/79)

	Depth Interval (cm)							
	0-2		2-5		5-10		10-15	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans								
Nemertean sp.	-	-	-	-	-	-	2	7.3
Polychaetes								
Eteone heteropoda	1	0.4	-	-	-	-	-	-
Glycera dibranchiata	-	-	1	0.5	-	-	-	-
Heteromastus filiformis	1	0.2	-	-	-	-	-	-
Nereis succinea	3	0.9	1	1.3	-	-	-	-
Paraprionspio pinnata	-	-	1	1.8	1	2.6	-	-
Streblospio benedicti	21	2.0	3	0.3	-	-	-	-
Molluscs								
Macoma balthica	-	-	-	-	1	14.4	-	-
Mulinia lateralis	8	29.3	2	11.4	-	-	-	-

Station 24

(6/27/79)

	Depth Interval (cm)			
	0-2		2-5	
	#	B (mg)	#	B (mg)
Polychaetes				
Pseudeurythoe ambigua	-	-	1	2.0

Station 25

(6/27/79)

	Depth Interval (cm)							
	0-2		2-5		5-10		10-15	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans								
Cerebratulus lacteus	1	0.6	3	2.7	-	-	-	-
Nemertean sp.	1	0.4	1	0.7	-	-	-	-
Polychaetes								
Glycera dibranchiata	-	-	-	-	2	190.4	-	-
Heteromastus filiformis	4	0.7	2	0.4	-	-	2	0.4
Nereis succinea	19	73.9	7	30.5	3	14.8	1	4.7
Pectinaria gouldii	2	1.3	1	0.8	-	-	-	-
Streblospio benedicti	11	1.1	2	0.2	-	-	-	-
Molluscs								
Macoma mitchelli	-	-	-	-	1	2.3	-	-
Mulinia lateralis	3	5.4	5	9.6	-	-	-	-

Station 51

(7/5/79)

	Depth Interval (cm)					
	0-2		2-5		5-10	
	#	B (mg)	#	B (mg)	#	B (mg)
Oligochaetes						
Oligochaete sp.	2	0.1	3	0.2	-	-
Polychaetes						
Scolecolepides viridis	2	3.0	3	5.2	4	6.9
Crustaceans						
Cyathura polita	1	0.4	5	2.3	-	-
Insects						
Chironomus sp.	11	2.2	5	1.1	5	1.2
Cryptochironomus sp.	2	0.4	-	-	-	-

Station 52

(7/4/79)

	Depth Interval (cm)											
	0-2		2-5		5-10		10-15		15-20		20-30	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans												
Cerebratulus lacteus	-	-	-	-	-	-	-	-	-	-	2	16.2
Oligochaetes												
Oligochaete sp.	-	-	20	0.7	3	0.2	22	1.0	2	0.1	2	0.1
Polychaetes												
Scolecolepides viridis	16	8.3	34	16.6	17	8.5	6	3.2	1	0.5	-	-
Molluscs												
Rangia cuneata	-	-	1	12.3	-	-	-	-	-	-	-	-
Crustaceans												
Cyathura polita	2	0.2	1	0.4	1	0.4	-	-	-	-	-	-
Leptocheirus plumulosus	12	2.6	2	0.5	-	-	-	-	-	-	-	-
Insects												
Procladius sp.	1	0.2	-	-	-	-	-	-	-	-	-	-

Station 53

(7/5/79)

	Depth Interval (cm)							
	0-2		2-5		5-10		10-15	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Oligochaetes								
Oligochaete sp.	-	-	5	0.2	18	0.9	7	0.3
Polychaetes								
Heteromastus filiformis	-	-	-	-	1	0.2	-	-
Scolecolepides viridis	-	-	3	1.5	7	4.1	1	0.6
Insects								
Chironomus sp.	3	0.6	1	0.1	-	-	-	-
Coelotanypus sp.	1	0.1	1	0.1	-	-	-	-
Procladius sp.	1	0.1	4	0.4	1	0.1	-	-

Station 54

(7/3/79)

	Depth Interval (cm)											
	0-2		2-5		5-10		10-15		15-20		20-30	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans												
Nemertean sp.	1	1.0	1	0.9	-	-	1	1.5	-	-	1	3.2
Oligochaetes												
Oligochaete sp.	5	0.2	13	0.5	2	0.1	-	-	-	-	-	-
Polychaetes												
Eteone heteropoda	2	0.8	1	0.5	-	-	-	-	-	-	-	-
Heteromastus filiformis	1	0.3	10	5.0	33	13.2	-	-	1	0.4	3	1.8
Nereis succinea	12	33.0	10	37.7	2	51.0	2	13.9	-	-	-	-
Scolecolepides viridis	2	3.0	6	15.0	2	5.1	-	-	-	-	-	-
Streblospio benedicti	10	1.0	-	-	-	-	-	-	-	-	-	-
Molluscs												
Macoma balthica	31	71.2	18	264.3	5	98.4	7	833.8	11	1429.2	13	1310.2
Macoma mitchelli	2	5.7	2	6.1	-	-	-	-	-	-	-	-
Mulinia lateralis	7	0.4	-	-	-	-	-	-	-	-	-	-
Mya arenaria	-	-	1	100.0	4	825.4	-	-	-	-	-	-
Crustaceans												
Leptocheirus plumulosus	83	11.6	6	0.8	3	0.4	-	-	-	-	-	-

Station 55

(7/3/79)

No organisms found.

Station 56

(7/3/79)

	Depth Interval (cm)					
	0-2		2-5		5-10	
	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans						
Nemertean sp.	1	0.7	2	2.5	1	0.7
Polychaetes						
Eteone heteropoda	4	1.6	-	-	-	-
Glycinde solitaria	2	0.9	-	-	-	-
Nereis succinea	2	17.8	-	-	1	9.4
Paraprionspio pinnata	3	2.9	10	16.0	-	-
Pectinaria gouldii	1	0.8	1	5.3	-	-
Scolecolepides viridis	2	2.5	1	1.5	-	-
Streblospio benedicti	140	13.4	-	-	-	-
Molluscs						
Macoma balthica	3	2.0	2	16.1	1	7.4
Mulinia lateralis	3	3.3	1	1.5	-	-
Crustaceans						
Leptocheirus plumulosus	2	0.3	-	-	-	-
Insects						
Chironomus sp.	1	0.4	-	-	-	-

Station 57

(6/30/79)

	Depth Interval (cm)							
	0-2		2-5		5-10		10-15	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Polychaetes								
Eteone heteropoda	1	0.2	1	0.2	-	-	-	-
Glycera dibranchiata	-	-	1	0.6	-	-	-	-
Glycinde solitaria	-	-	1	0.8	-	-	-	-
Nereis succinea	2	0.2	-	-	-	-	-	-
Streblospio benedicti	26	2.5	7	0.7	-	-	-	-
Molluscs								
Macoma balthica	2	3.4	2	6.4	10	9.0	2	42.9
Mulinia lateralis	1	8.2	-	-	-	-	-	-
Crustaceans								
Leptocheirus plumulosus	4	1.9	-	-	-	-	-	-

Station 58

(6/26/79)

No organisms found.

Station 59

(6/29/79)

	Depth Interval (cm)									
	0-2		2-5		5-10		10-15		15-18	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans										
Cerebratulus lacteus	1	0.2	6	2.0	10	4.2	4	1.6	-	-
Nemertean sp.	-	-	1	0.3	-	-	-	-	-	-
Oligochaetes										
Oligochaete sp.	-	-	1	0.1	-	-	-	-	-	-
Polychaetes										
Glycera dibranchiata	-	-	-	-	1	0.4	-	-	-	-
Heteromastus filiformis	-	-	1	0.6	5	7.2	2	0.4	1	0.3
Nereis succinea	1	0.2	-	-	-	-	-	-	-	-
Paraprionspio pinnata	-	-	1	1.6	1	1.4	1	1.7	-	-
Streblospio benedicti	26	2.4	6	0.6	-	-	-	-	-	-
Molluscs										
Lyonsia hyalina	1	0.3	-	-	-	-	-	-	-	-
Macoma balthica	1	0.2	2	1.2	-	-	-	-	-	-
Macoma mitchelli	1	0.5	-	-	1	1.2	1	1.5	1	2.1
Mulinia lateralis	3	8.0	1	2.1	-	-	-	-	-	-

Station 59 (cont.)

(6/29/79)

	Depth Interval (cm)									
	0-2		2-5		5-10		10-15		15-18	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Molluscs (cont.)										
Mya arenaria	-	-	-	-	1	56.4	-	-	-	-
Retusa canaliculata	1	0.2	-	-	-	-	-	-	-	-
Crustaceans										
Leptocheirus plumulosus	3	0.3	4	0.9	3	0.4	-	-	-	-
Neomysis americana	1	0.2	-	-	-	-	-	-	-	-

Station 60

(6/29/79)

	Depth Interval (cm)							
	0-2		2-5		5-10		10-15	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nererteans								
Nemertean sp.	-	-	-	-	1	4.7	-	-
Polychaetes								
Eteone heteropoda	1	0.3	-	-	-	-	-	-
Heteromastus filiformis	5	1.0	3	0.8	2	0.5	1	0.3
Nereis succinea	9	1.6	16	6.6	2	9.0	1	16.3
Scolecolepides viridis	1	4.0	1	3.8	-	-	-	-
Streblospio benedicti	225	21.3	109	10.9	6	0.6	-	-
Molluscs								
Macoma balthica	11	16.7	4	12.9	1	21.2	-	-
Macoma mitchelli	1	0.6	-	-	1	17.2	-	-
Mulinia lateralis	5	13.8	1	5.5	-	-	-	-
Crustaceans								
Leptocheirus plumulosus	122	84.3	33	22.8	4	0.8	-	-

Station 61

(6/29/79)

	Depth Interval (cm)					
	0-2		2-5		5-10	
	#	B (mg)	#	B (mg)	#	B (mg)
Polychaetes						
Eteone heteropoda	1	1.2	-	-	-	-
Glycera dibranchiata	3	2.4	-	-	-	-
Nereis succinea	2	1.2	1	0.9	-	-
Paraprionspio pinnata	1	2.1	2	5.3	-	-
Scolecolepides viridis	-	-	1	6.2	1	6.0
Streblospio benedicti	53	5.1	-	-	-	-
Molluscs						
Macoma balthica	13	3.8	-	-	-	-
Macoma mitchelli	3	2.9	-	-	-	-
Crustaceans						
Leptocheirus plumulosus	10	10.4	-	-	-	-

Station 62

(6/28/79)

	Depth Interval (cm)			
	0-2		2-5	
	#	B (mg)	#	B (mg)
Polychaetes				
Pseudeurythoe ambigua	-	-	1	1.2

Station 63

(6/28/79)

	Depth Interval (cm)					
	0-2		2-5		5-10	
	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans						
Cerebratulus lacteus	-	-	1	0.3	-	-
Nemertean sp.	-	-	-	-	3	1.7
Polychaetes						
Glycinde solitaria	3	1.2	2	1.1	-	-
Heteromastus filiformis	2	0.4	-	-	2	3.3
Nereis succinea	4	1.3	2	1.0	-	-
Streblospio benedicti	132	12.6	-	-	-	-
Molluscs						
Macoma balthica	8	1.5	3	11.2	1	2.0
Macoma mitchelli	3	3.1	2	5.3	1	21.2
Mulinia lateralis	1	0.2	-	-	-	-
Crustaceans						
Leptocheirus plumulosus	12	6.4	3	2.1	-	-

Station 64

(6/28/79)

Depth Interval (cm)

	0-2		2-5		5-10		10-15		15-20	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Nemerteans										
Nemertean sp.	-	-	1	1.2	2	1.0	-	-	-	-
Oligochaetes										
Oligochaete sp.	-	-	11	0.1	-	-	-	-	-	-
Polychaetes										
Heteromastus filiformis	2	0.4	1	0.2	3	4.1	1	2.0	-	-
Nereis succinea	-	-	-	-	1	2.1	-	-	-	-
Paraprionspio pinnata	-	-	2	3.5	-	-	-	-	-	-
Scolecolepides viridis	-	-	1	4.0	-	-	-	-	-	-
Streblospio benedicti	24	2.3	2	0.2	-	-	-	-	-	-
Molluscs										
Macoma balthica	-	-	3	6.6	6	43.1	3	48.0	1	13.7
Mulinia lateralis	5	0.2	-	-	-	-	-	-	-	-
Crustaceans										
Ampelisca abdita	1	0.1	-	-	-	-	-	-	-	-
Chirodotea caeca	1	0.1	-	-	-	-	-	-	-	-
Cyclaspis varians	78	2.2	7	0.2	-	-	-	-	-	-

Station 65

(6/26/79)

	Depth Interval (cm)											
	0-2		2-5		5-10		10-15		15-20		20-30	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Platyhelminthes												
Stylochus ellipticus	7	10.1	3	4.8	-	-	-	-	-	-	-	-
Nemerteans												
Nemertean sp.	4	2.1	-	-	6	8.9	-	-	-	-	-	-
Polychaetes												
Amphicteus floridans	-	-	-	-	4	41.1	-	-	-	-	-	-
Eteone heteropoda	24	12.6	6	2.4	-	-	-	-	-	-	-	-
Glycera dibranchiata	4	2.0	5	9.6	2	1.2	1	151.4	-	-	-	-
Heteromastus filiformis	16	2.2	3	0.5	2	0.3	3	0.7	3	0.9	1	0.3
Loimia medusa	-	-	-	-	3	679.1	-	-	-	-	-	-
Nereis succinea	16	30.9	7	3.8	4	1.8	3	3.8	-	-	-	-
Paraprionspio pinnata	2	2.1	7	11.2	2	3.9	-	-	-	-	-	-
Pectinaria gouldii	401	657.6	191	808.5	15	14.3	4	5.2	-	-	-	-
Polydora ligni	24	2.4	1	0.1	-	-	-	-	-	-	-	-
Pseudeurythoe ambigua	-	-	3	5.4	15	15.5	3	3.9	-	-	-	-
Streblospio benedicti	185	17.8	30	3.0	-	-	-	-	-	-	-	-

Station 65 (cont.)

(6/26/79)

	Depth Interval (cm)											
	0-2		2-5		5-10		10-15		15-20		20-30	
	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)	#	B (mg)
Molluscs												
Lyonsia hyalina	14	85.5	-	-	-	-	-	-	-	-	-	-
Macoma balthica	1	1.3	10	85.1	12	135.3	1	6.8	-	-	-	-
Macoma mitchelli	1	0.5	-	-	-	-	-	-	-	-	-	-
Mulinia lateralis	77	336.7	33	141.7	-	-	-	-	-	-	-	-
Mya arenaria	5	16.7	7	62.7	3	101.6	-	-	-	-	-	-
Retusa canaliculata	8	9.6	-	-	-	-	-	-	-	-	-	-
Crustaceans												
Ampelisca abdita	67	6.1	15	1.5	-	-	-	-	-	-	-	-
Chirodotea caeca	47	22.0	2	1.1	-	-	-	-	-	-	-	-
Cyclaspis varians	6	0.1	-	-	-	-	-	-	-	-	-	-

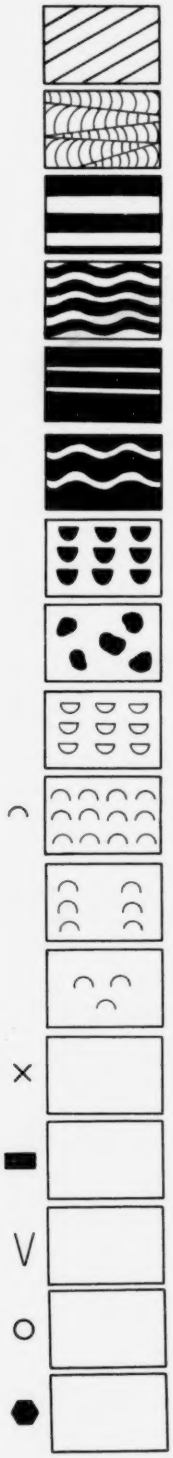
Appendix IV. Three-dimensional schematics illustrating sedimentary textures, physical structures and life positions of benthic organisms.

Note: Each animal represents ≤ 10 organisms.

KEY TO SEDIMENT TEXTURES

m-cS	Medium-Coarse Sand
f S	Fine Sand
m S	Muddy Sand
s M	Sandy Mud
M	Mud

KEY TO PHYSICAL SEDIMENTARY STRUCTURES



CROSS-BEDDING *(large scale)*

CROSS-BEDDING *(small scale)*

INTERBEDDED MUD and SAND

RIPPLE (wavy) LAMINATION

MUD LAMINATION

WAVY (mud) BEDDING

MUD FLASERS

MUD CLASTS

SAND LENSES

SHELL LAMINATION

DISPERSED SHELLS

SHELL POCKETS

PEBBLES

WOOD FRAGMENTS

PLANT FRAGMENTS

METHANE BUBBLES

SLAG

TYPING GUIDE SHEET

Station 1

(Fall 1978)

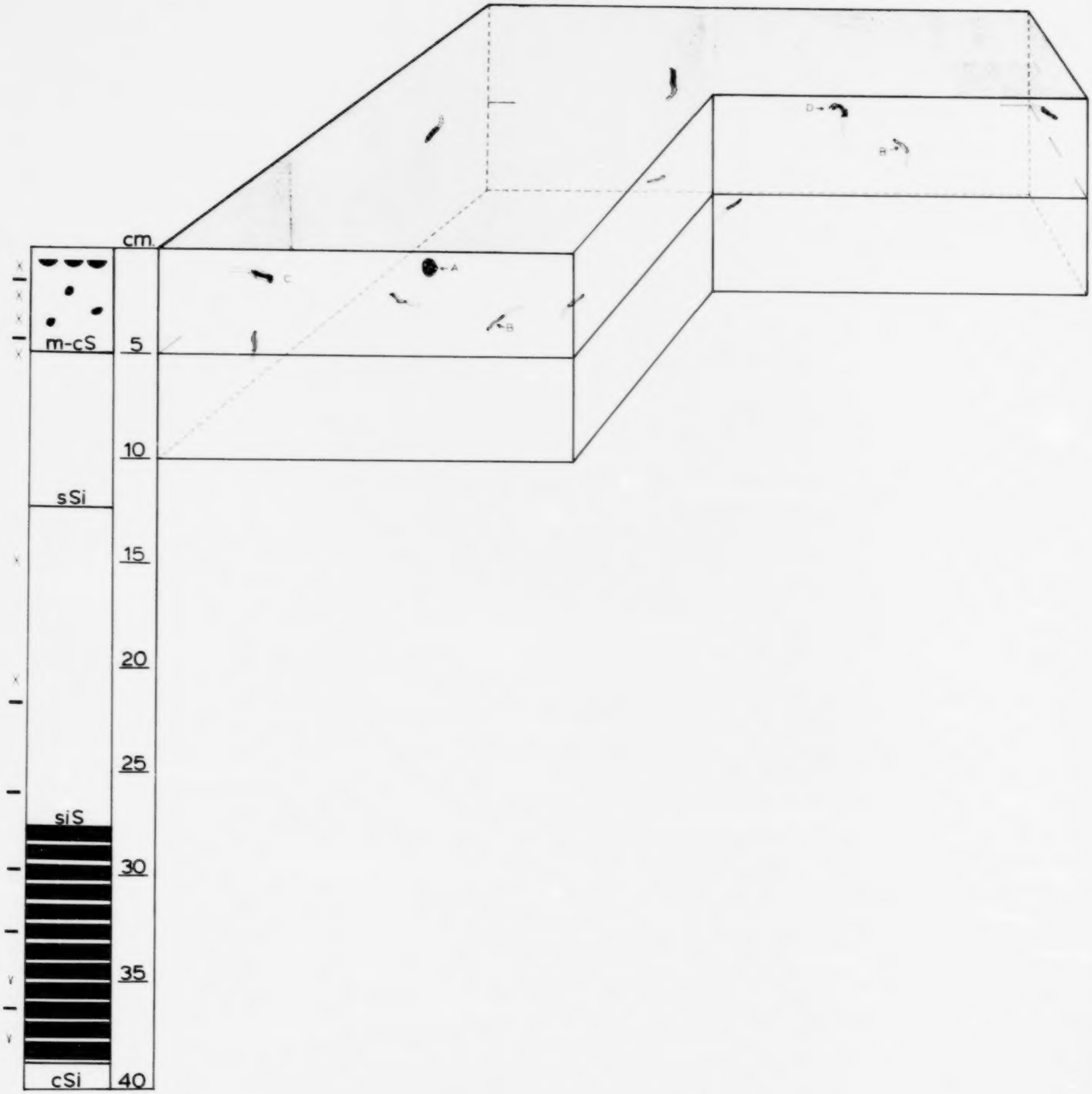
A. *Corbicula manilensis*

B. Oligochaete sp.

C. *Chironomus* sp.

D. Clinotanypus sp.

MD. 1


cm.
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m-cS
sSi
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cSi
A
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B

Station 2

(Fall 1978)

A. *Doridella obscura*

B. *Pisidium* sp.

C. Oligochaete sp.

D. *Scolecolepides viridis*

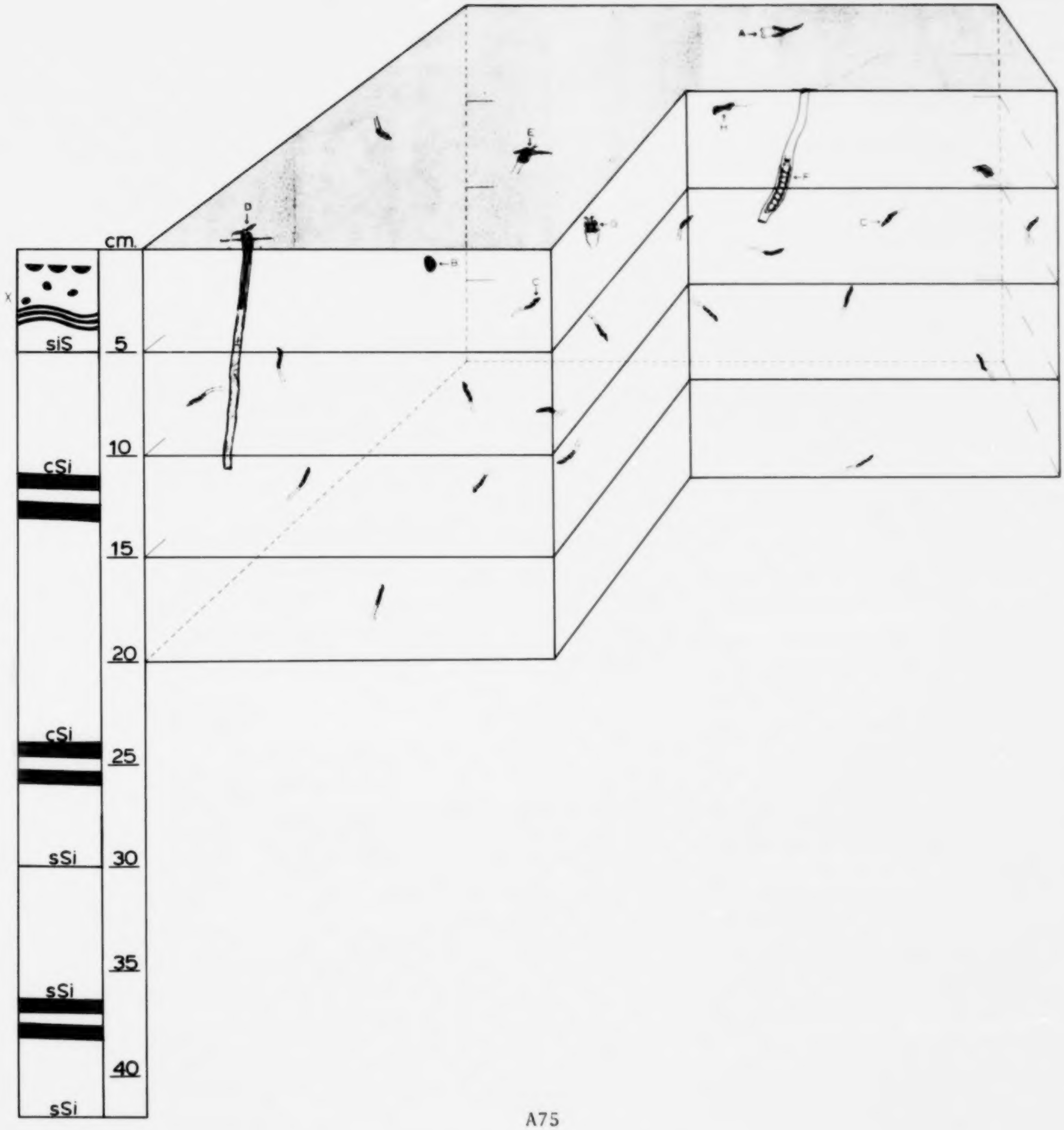
E. *Leptocheirus plumulosus*

F. *Cyathura polita*

G. *Chirodotea caeca*

H. *Chironomus* sp.

MD. 2


A
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cm.
X
siS
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cSi
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cSi
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sSi
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sSi
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sSi

Station 3

(Fall 1978)

A. *Mulinia lateralis*

B. *Scolecolepides viridis*

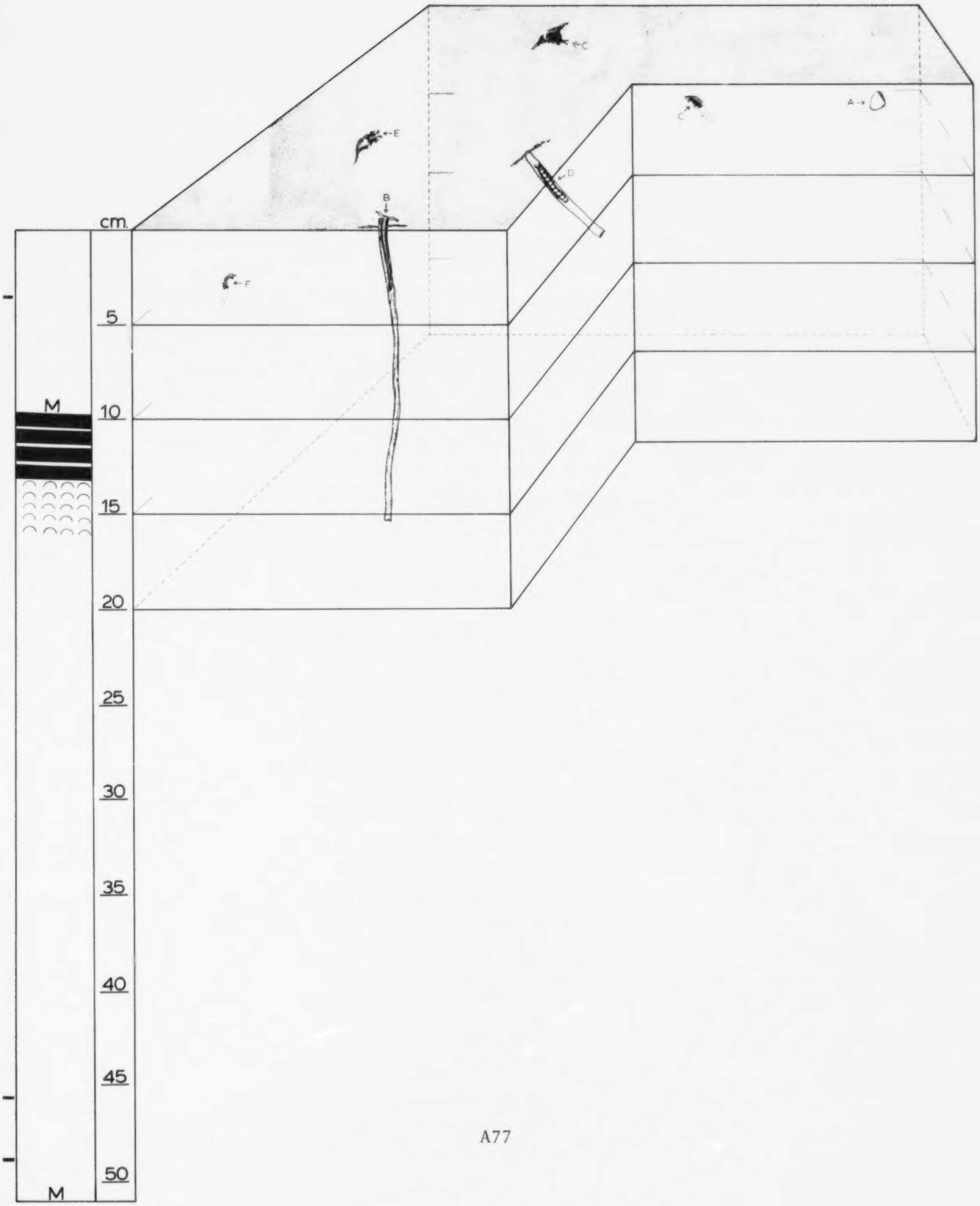
C. *Leptocheirus plumulosus*

D. *Cyathura polita*

E. *Chirodotea caeca*

F. *Clinotanypus* sp.

MD. 3


C
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cm.
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Station 4

(Fall 1978)

A. *Cerebratulus lacteus*

B. *Mulinia lateralis*

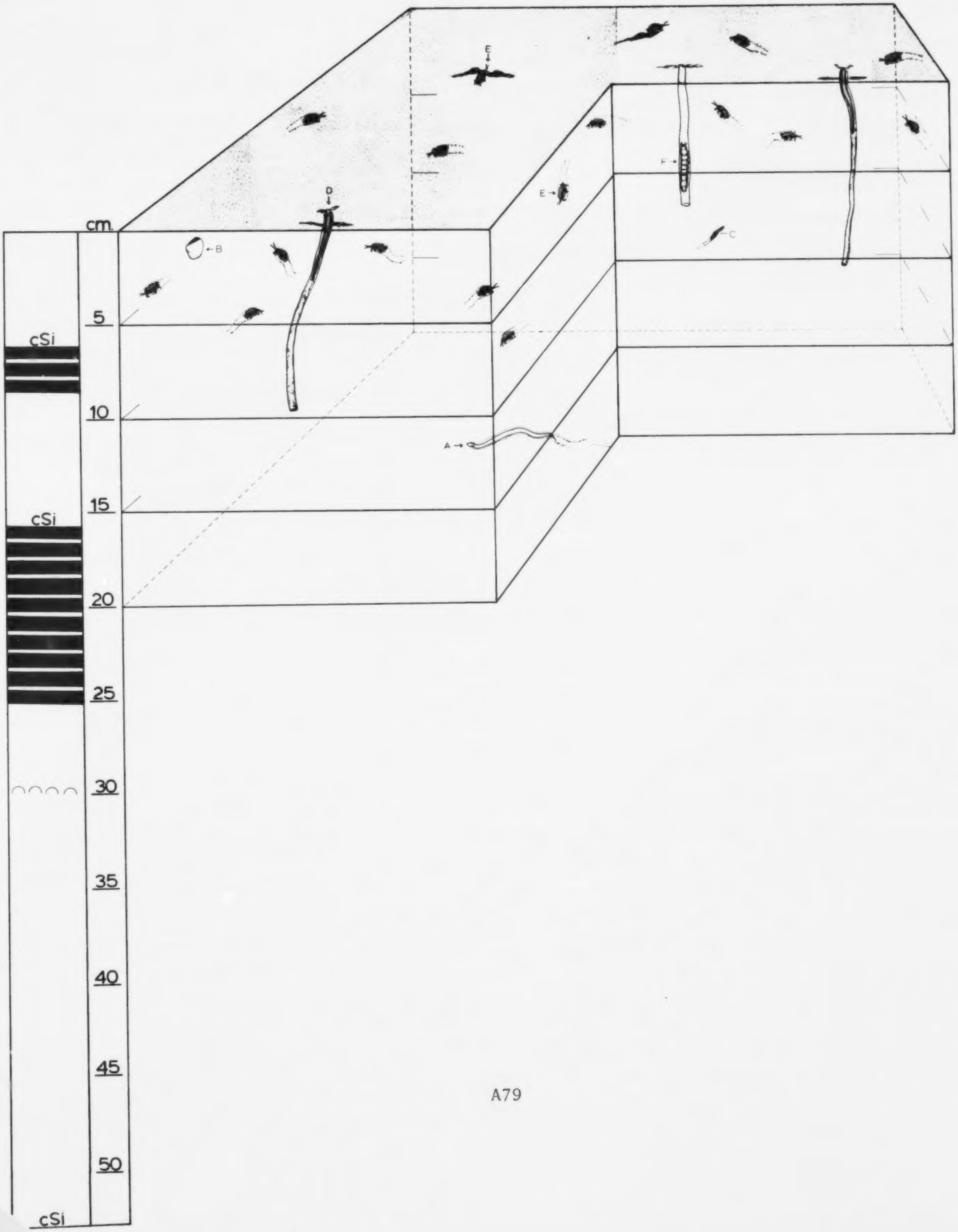
C. Oligochaete sp.

D. *Scolecolepides viridis*

E. *Leptocheirus plumulosus*

F. *Cyathura polita*

MD. 4


cm.
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cSi
cSi
cSi
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F

Station 5

(Fall 1978)

A. Oligochaete sp.

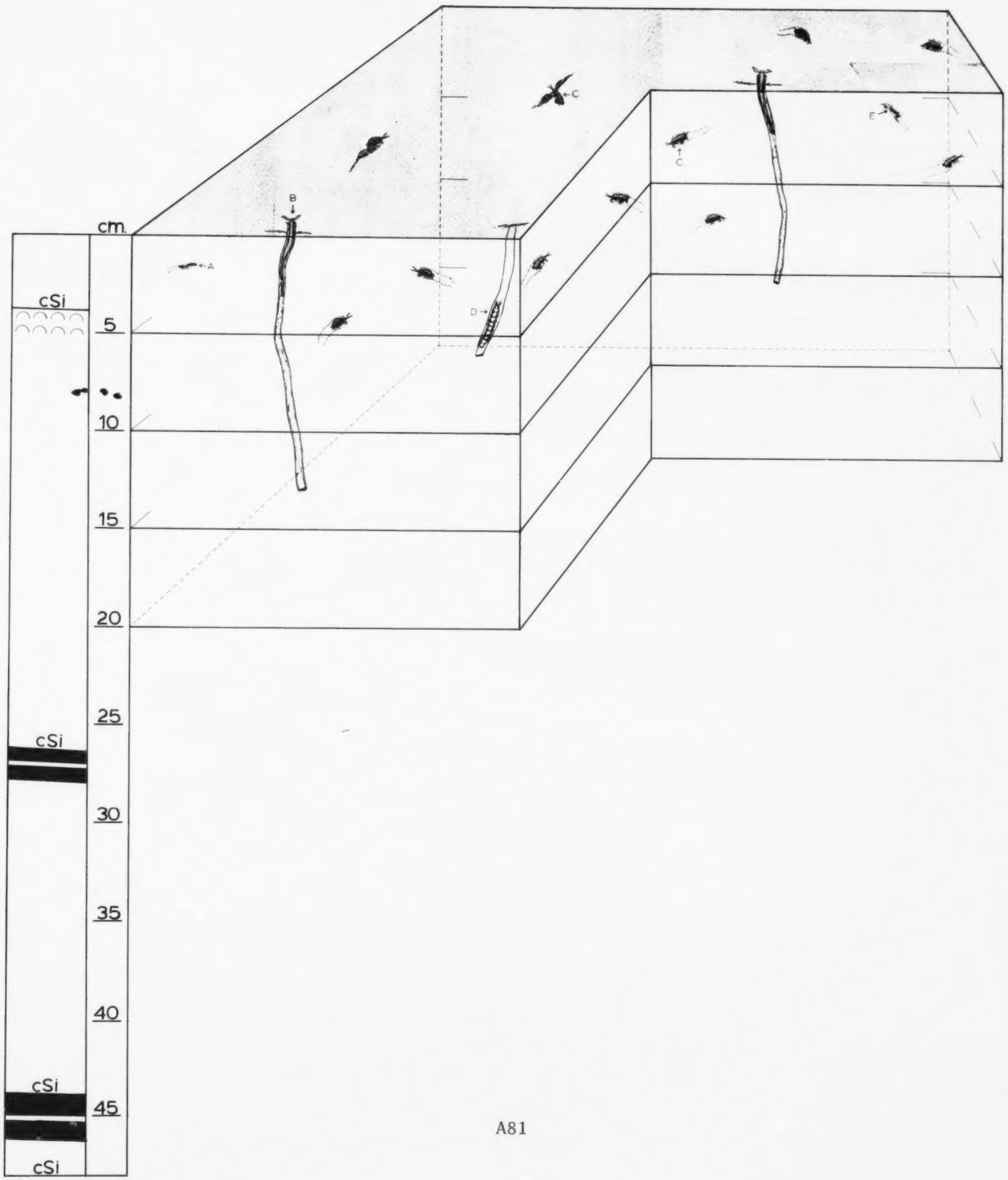
B. *Scolecolepides viridis*

C. *Leptocheirus plumulosus*

D. *Cyathura polita*

E. *Clinotanypus* sp.

MD. 5


cm.
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cSi
A
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Station 6

(Fall 1978)

A. *Macoma balthica*

B. *Macoma mitchelli*

C. Oligochaete sp.

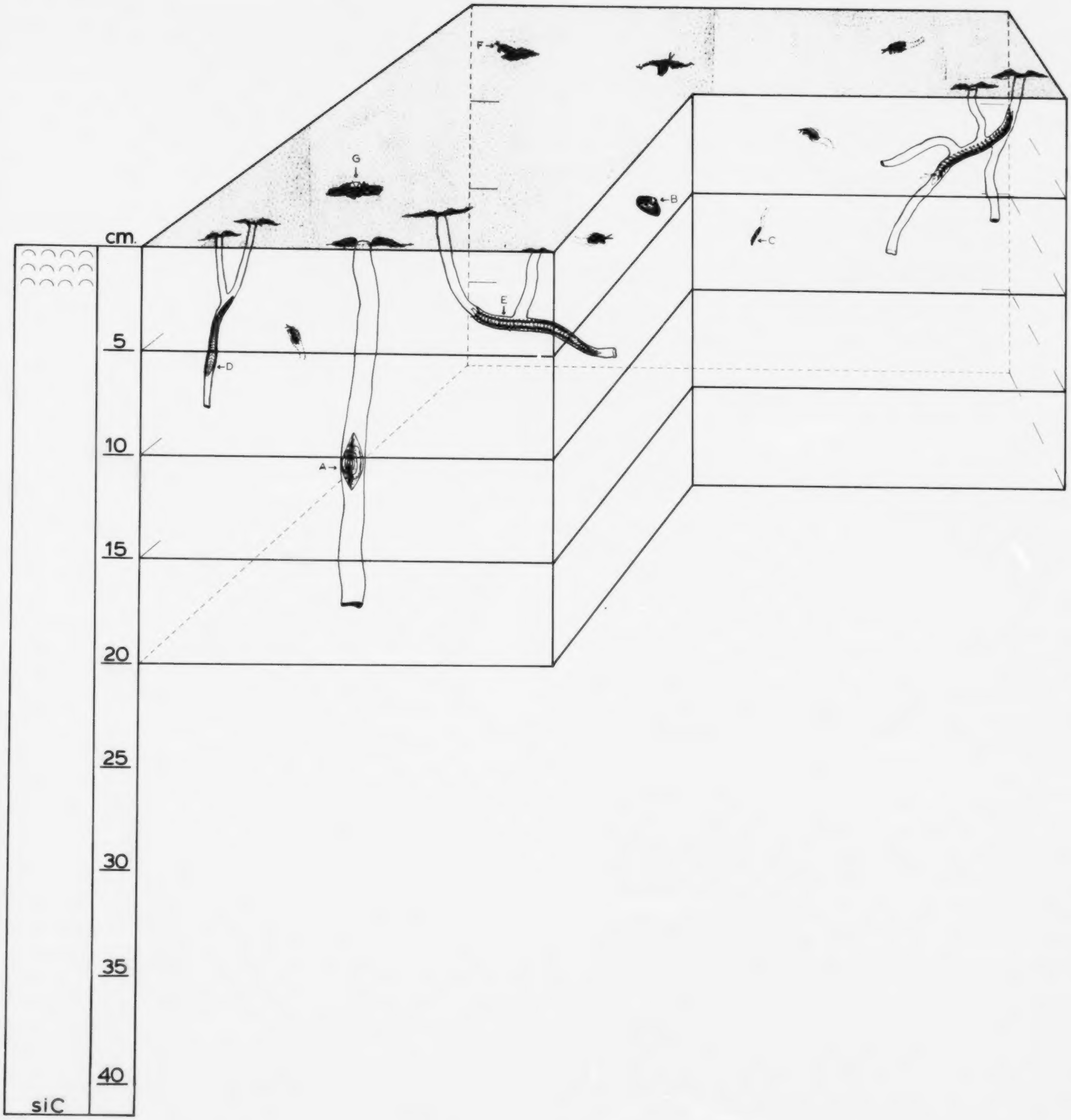
D. *Heteromastus filiformis*

E. *Nereis succinea*

F. *Leptocheirus plumulosus*

G. *Rhithropanopeus harissi*

MD. 6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Station 7

(Fall 1978)

A. *Cerebratulus lacteus*

B. *Macoma balthica*

C. *Macoma mitchelli*

D. Oligochaete sp.

E. *Heteromastus filiformis*

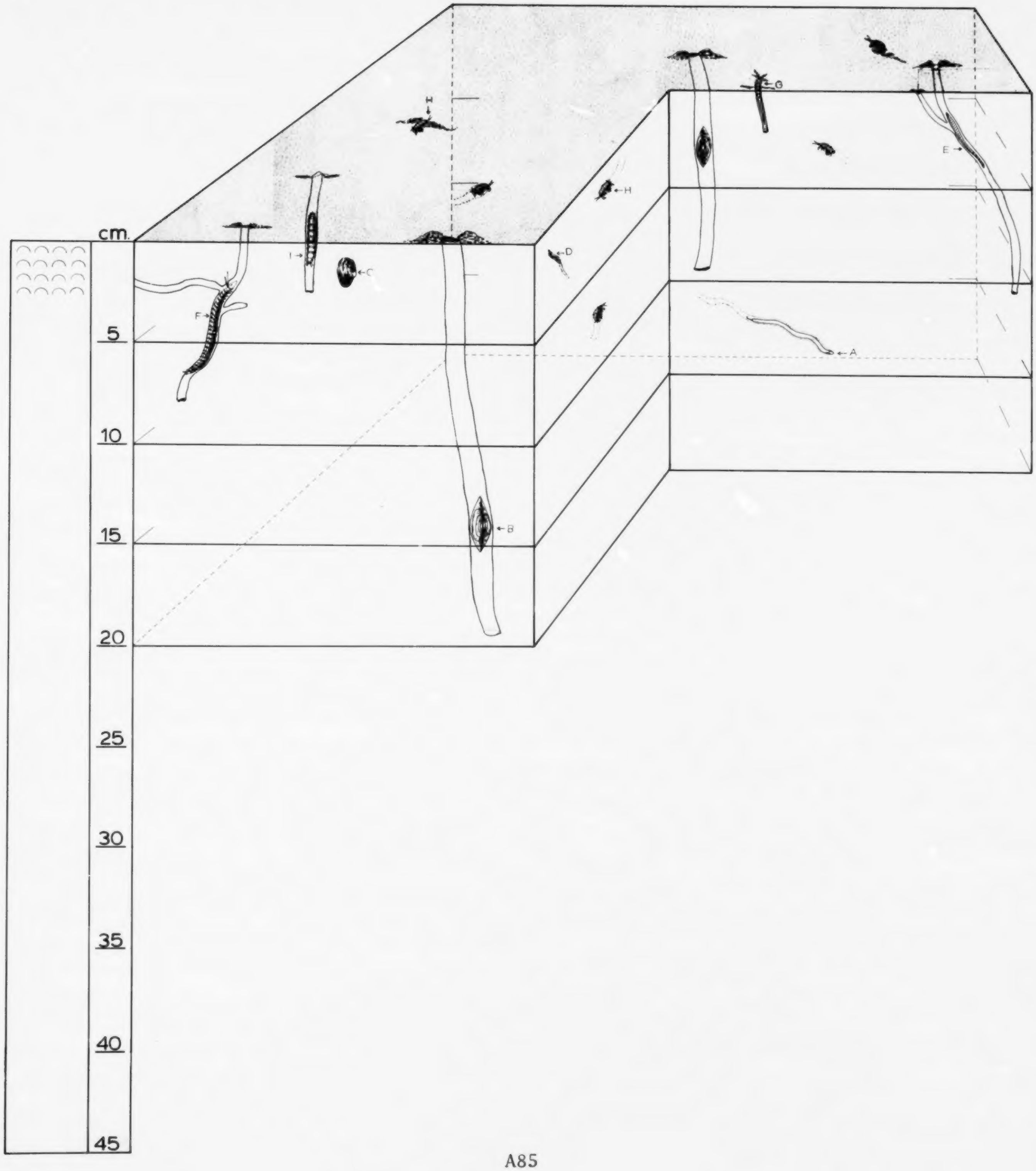
F. *Nereis succinea*

G. *Streblospio benedicti*

H. *Leptocheirus plumulosus*

I. *Cyathura polita*

MD. 7


cm.
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Station 8

(Fall 1978)

A. Macoma balthica

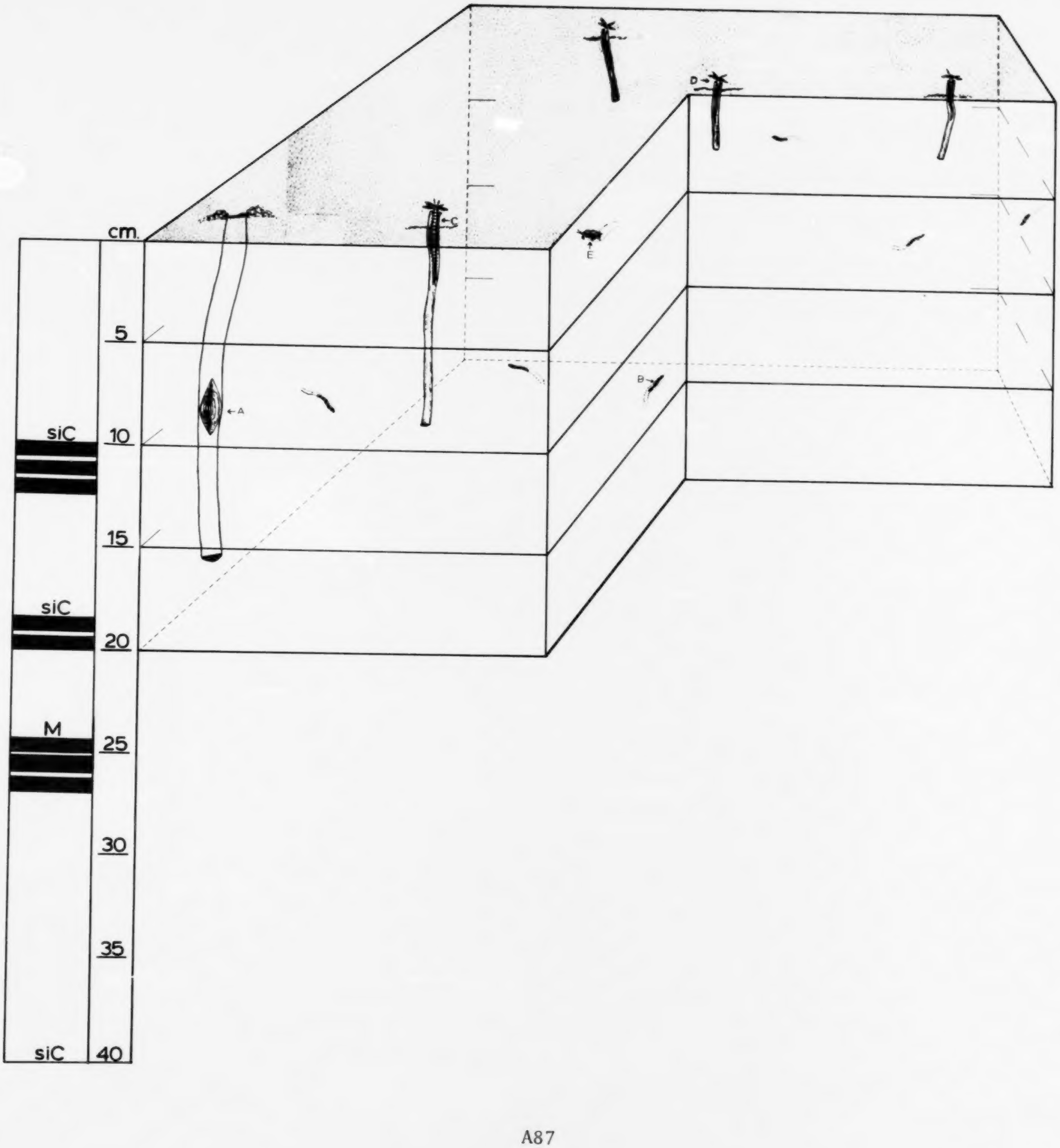
B. Oligochaete sp.

C. Paraprionspio pinnata

D. Streblospio benedicti

E. Leptocheirus plumulosus

MD. 8



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Station 9

(Fall 1978)

A. Cerebratulus lacteus

B. Macoma balthica

C. Macoma mitchelli

D. Oligochaete sp.

E. Nereis succinea

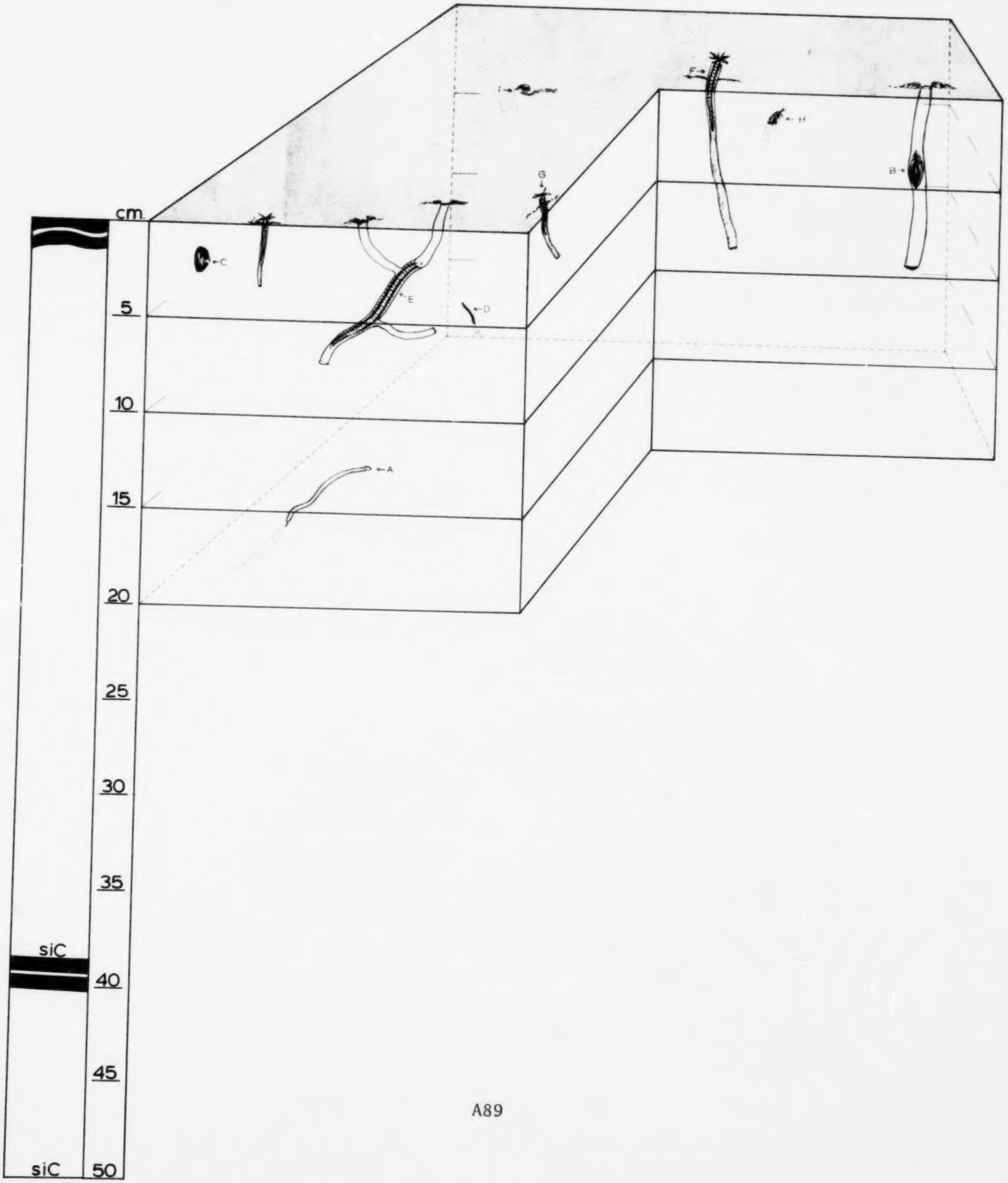
F. Paraprionspio pinnata

G. Streblospio benedicti

H. Leptocheirus plumulosus

I. Gammarus mucronatus

MD. 9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Station 10

(Fall 1978)

A. Macoma balthica

B. Oligochaete sp.

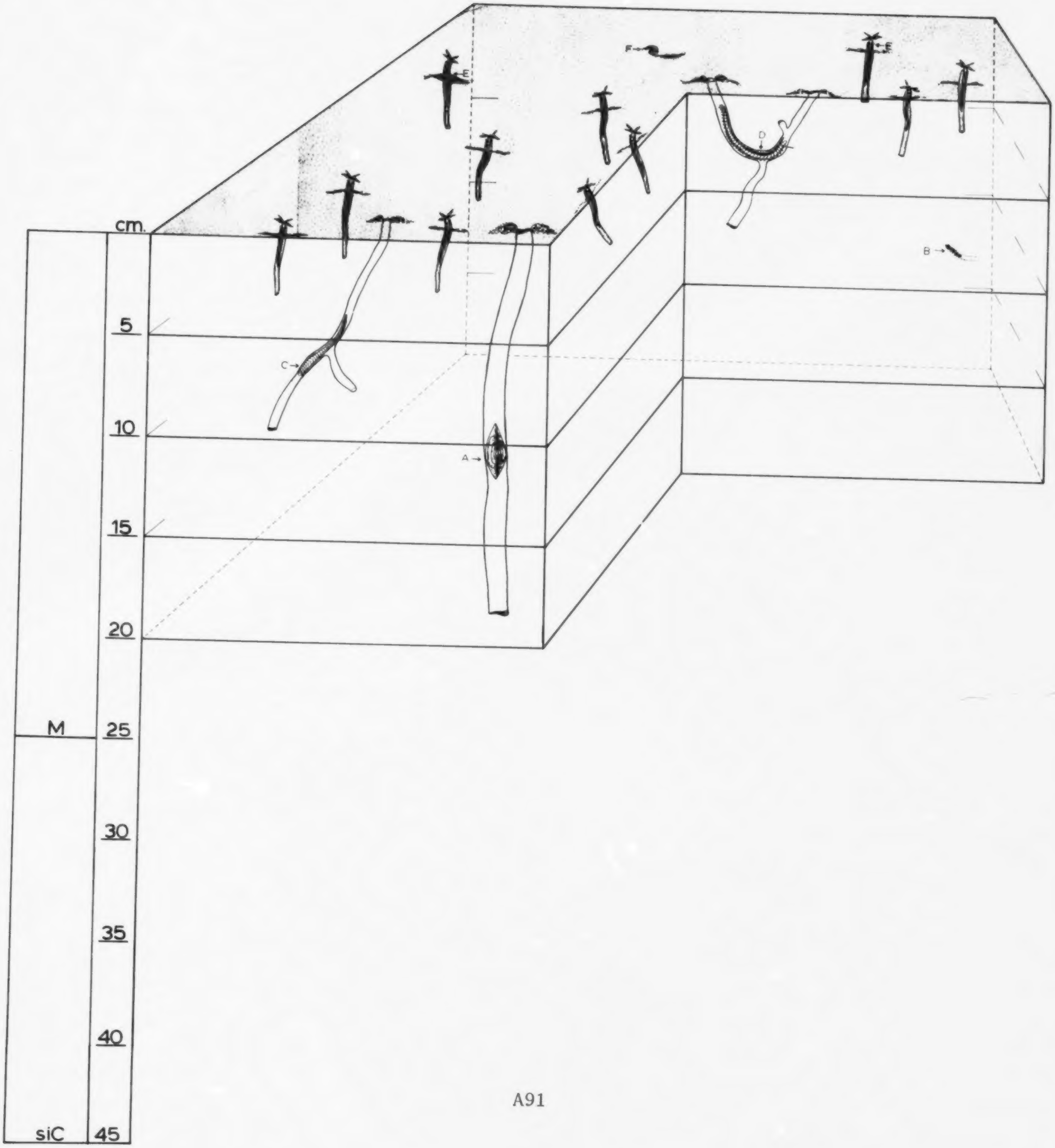
C. Heteromastus filiformis

D. Nereis succinea

E. Streblospio benedicti

F. Gammarus mucronatus

MD. 10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Station 11

(Fall 1978)

A. *Cerebratulus lacteus*

B. *Macoma balthica*

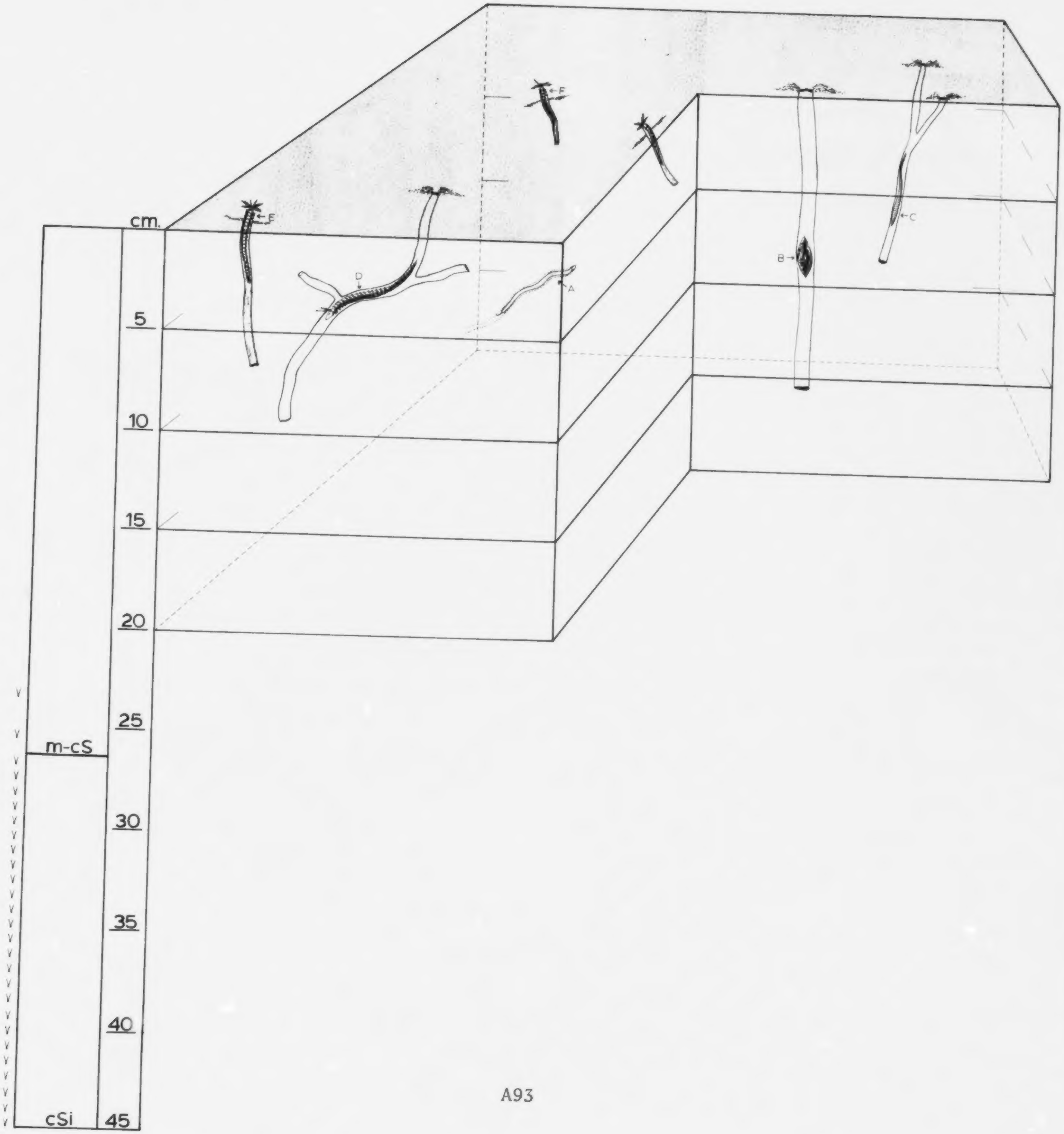
C. *Heteromastus filiformis*

D. *Nereis succinea*

E. *Paraprionspio pinnata*

F. *Streblospio benedicti*

MD. 11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Station 12

(Fall 1978)

A. *Cerebratulus lacteus*

B. *Macoma balthica*

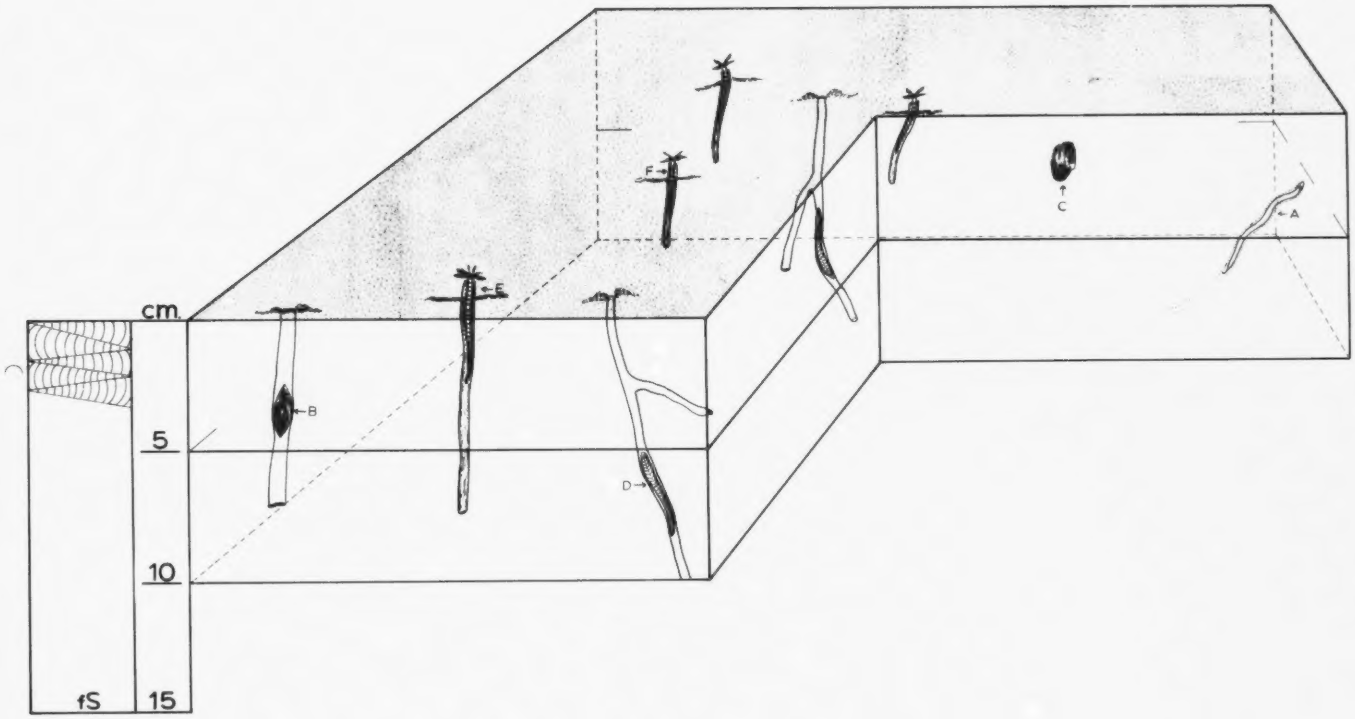
C. *Macoma mitchelli*

D. *Heteromastus filiformis*

E. *Paraprionspio pinnata*

F. *Streblospio benedicti*

MD. 12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Station 13

(Fall 1978)

A. Macoma mitchelli

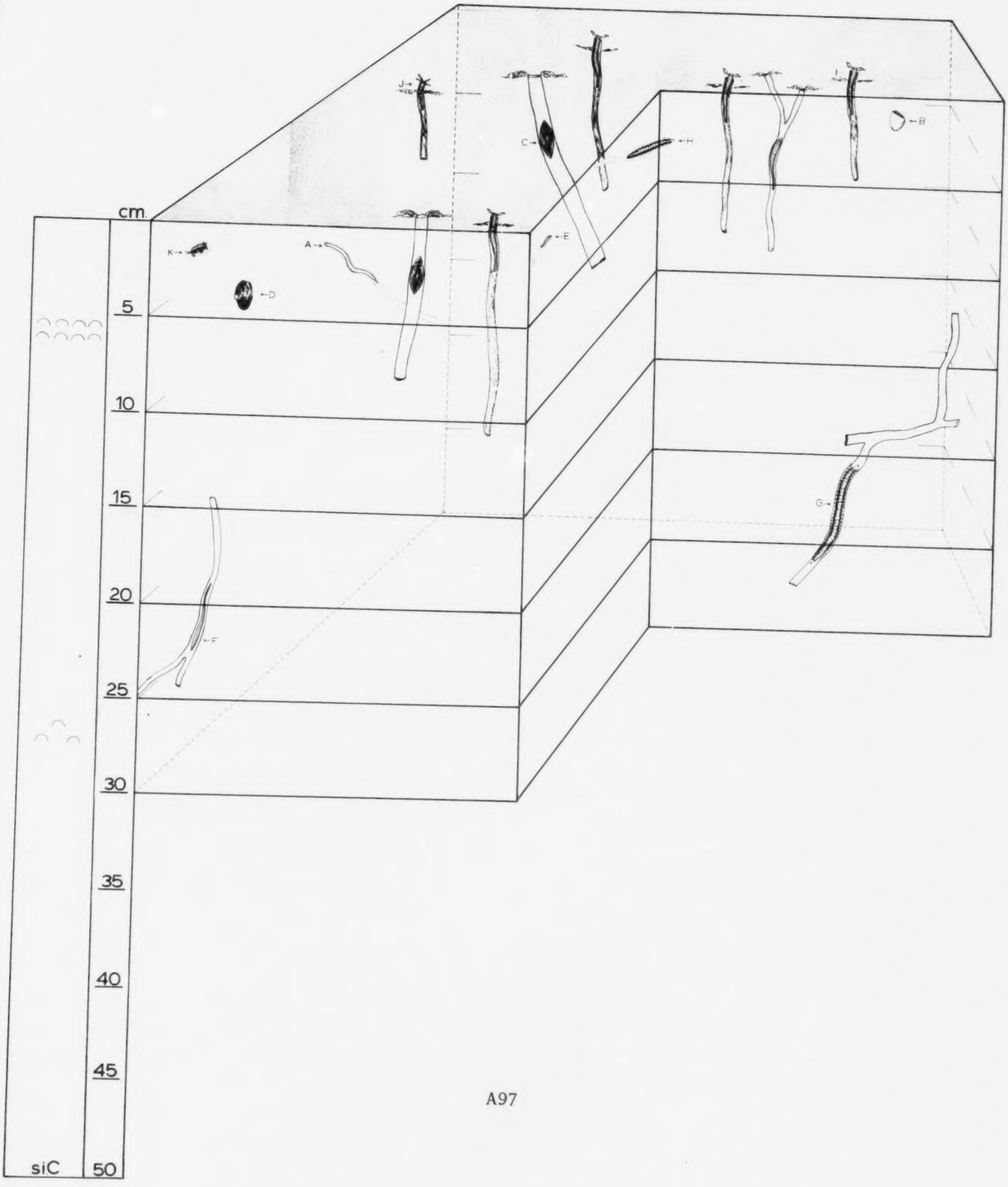
B. Glycinde solitaria

C. Nereis succinea

D. Paraprionspio pinnata

E. Streblospio benedicti

MD. 13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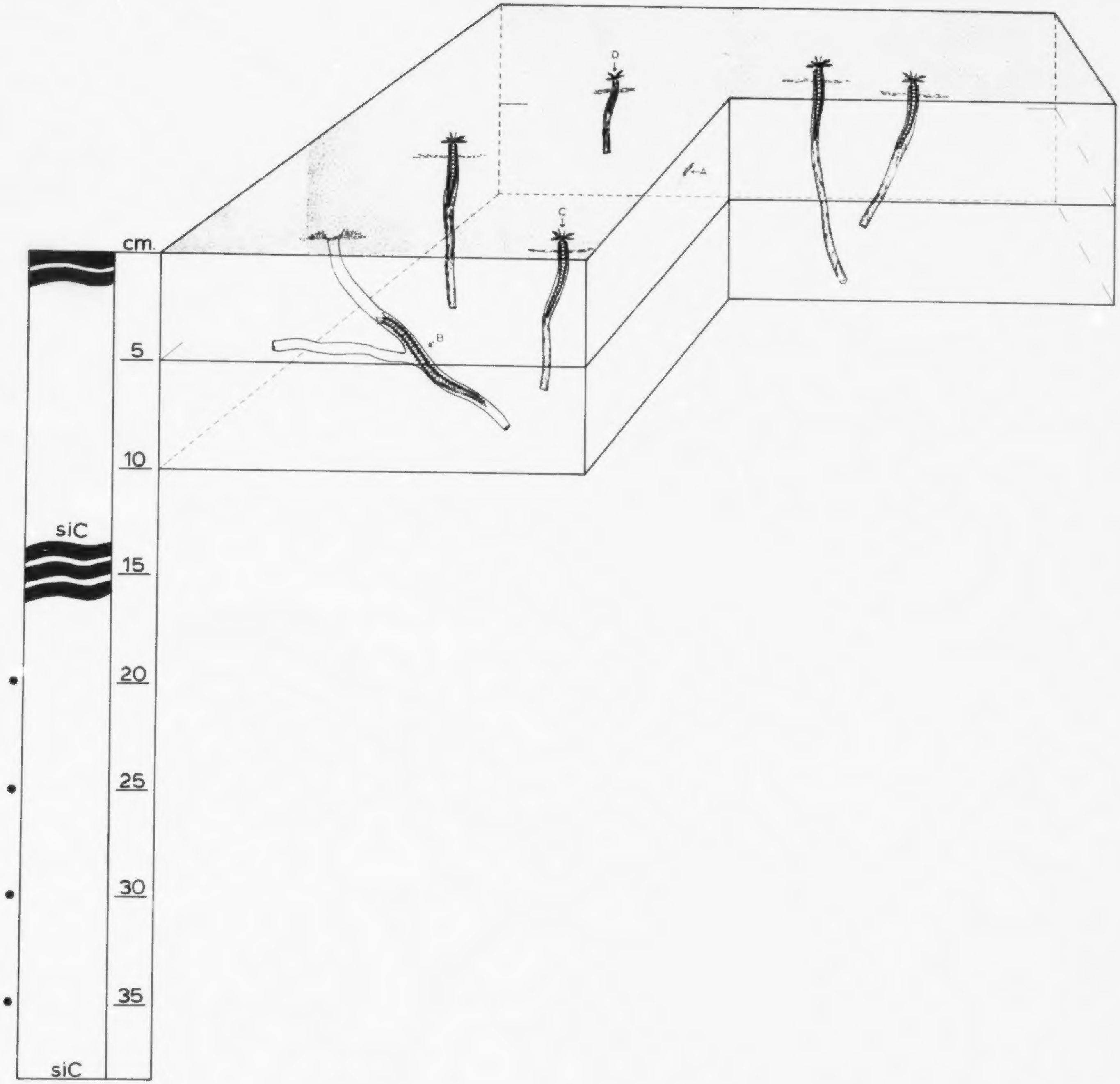
Station 14

(Fall 1978)

A. Oligochaete sp.
B. *Nereis succinea*
C. *Paraprionspio pinnata*
D. *Streblospio benedicti*

MD. 14



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Station 15

(Fall 1978)

A. *Macoma balthica*

B. *Macoma mitchelli*

C. Oligochaete sp.

D. *Heteromastus filiformis*

E. *Glycera dibranchiata*

F. *Glycinde solitaria*

G. *Nereis succinea*

H. *Scoloplos fragilis*

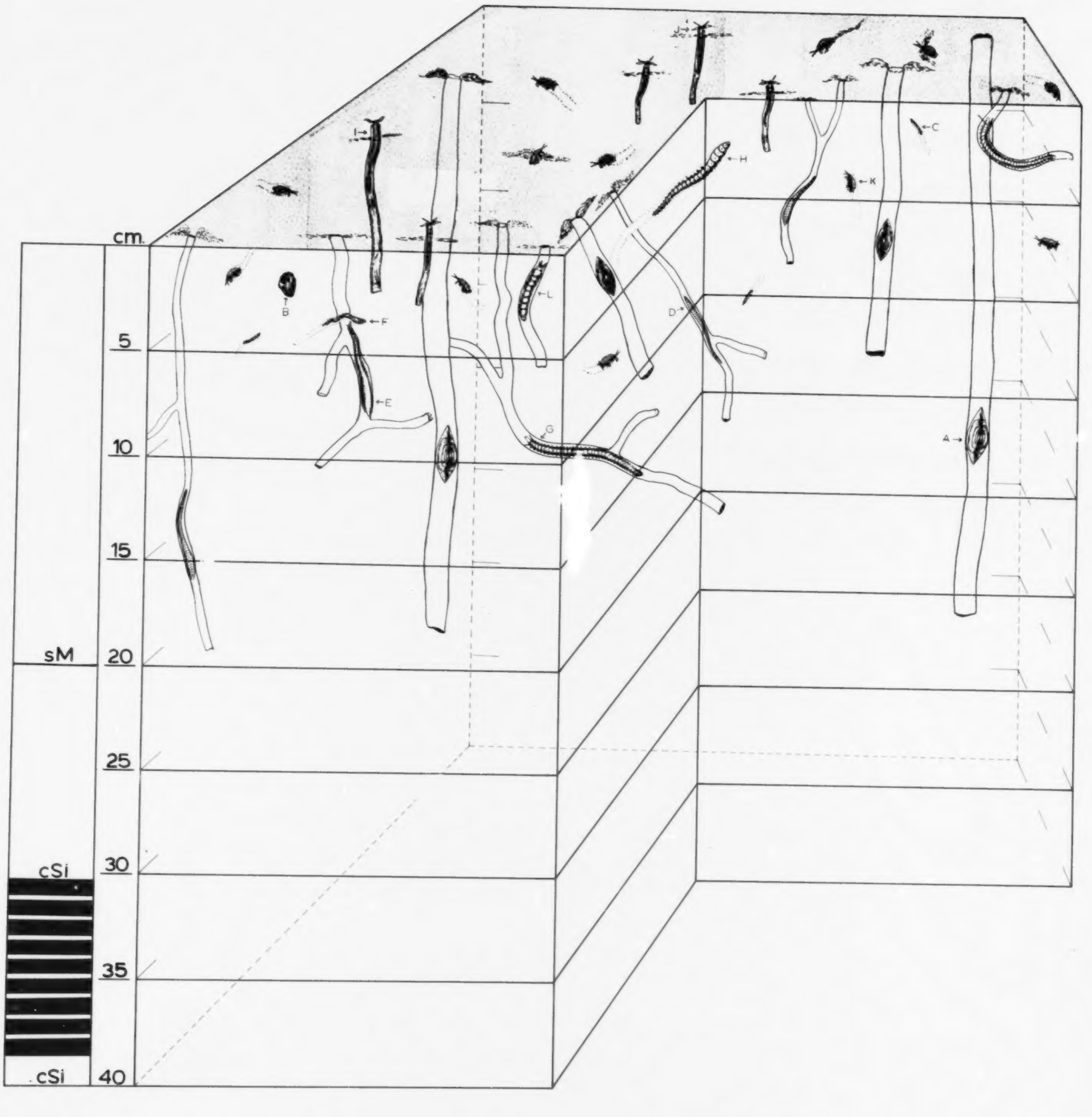
I. *Scolecolepides viridis*

J. *Streblospio benedicti*

K. *Leptocheirus plumulosus*

L. *Cyathura polita*

MD. 15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Station 16

(Fall 1978)

A. *Cerebratulus lacteus*

B. *Macoma balthica*

C. *Macoma mitchelli*

D. Oligochaete sp.

E. *Heteromastus filiformis*

F. *Glycinde solitaria*

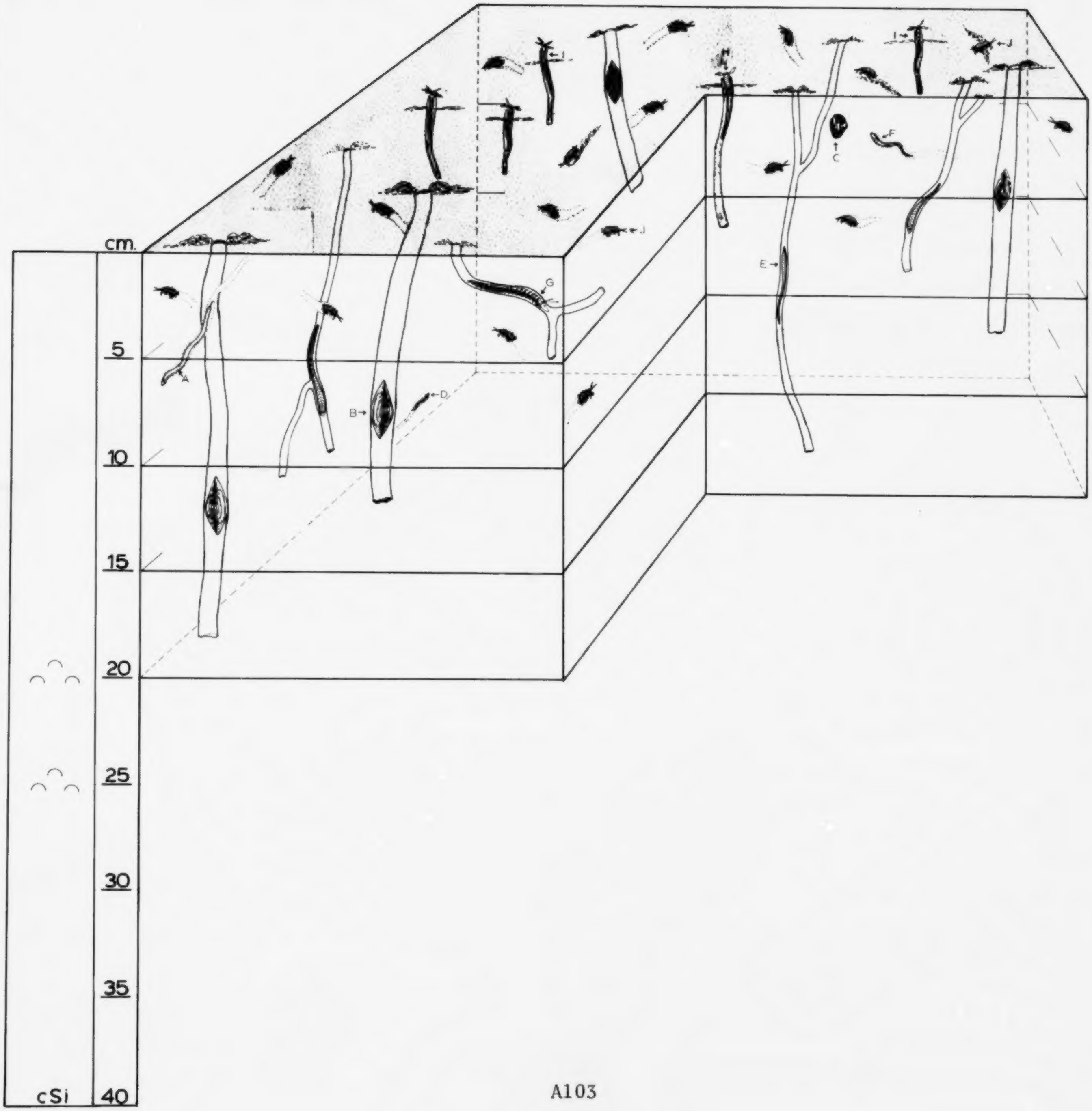
G. *Nereis succinea*

H. *Scolecolepides viridis*

I. *Streblospio benedicti*

J. *Leptocheirus plumulosus*

MD. 16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Station 17

(Fall 1978)

A. Macoma balthica

B. Macoma mitchelli

C. Oligochaete sp.

D. Heteromastus filiformis

E. Glycinde solitaria

F. Nereis succinea

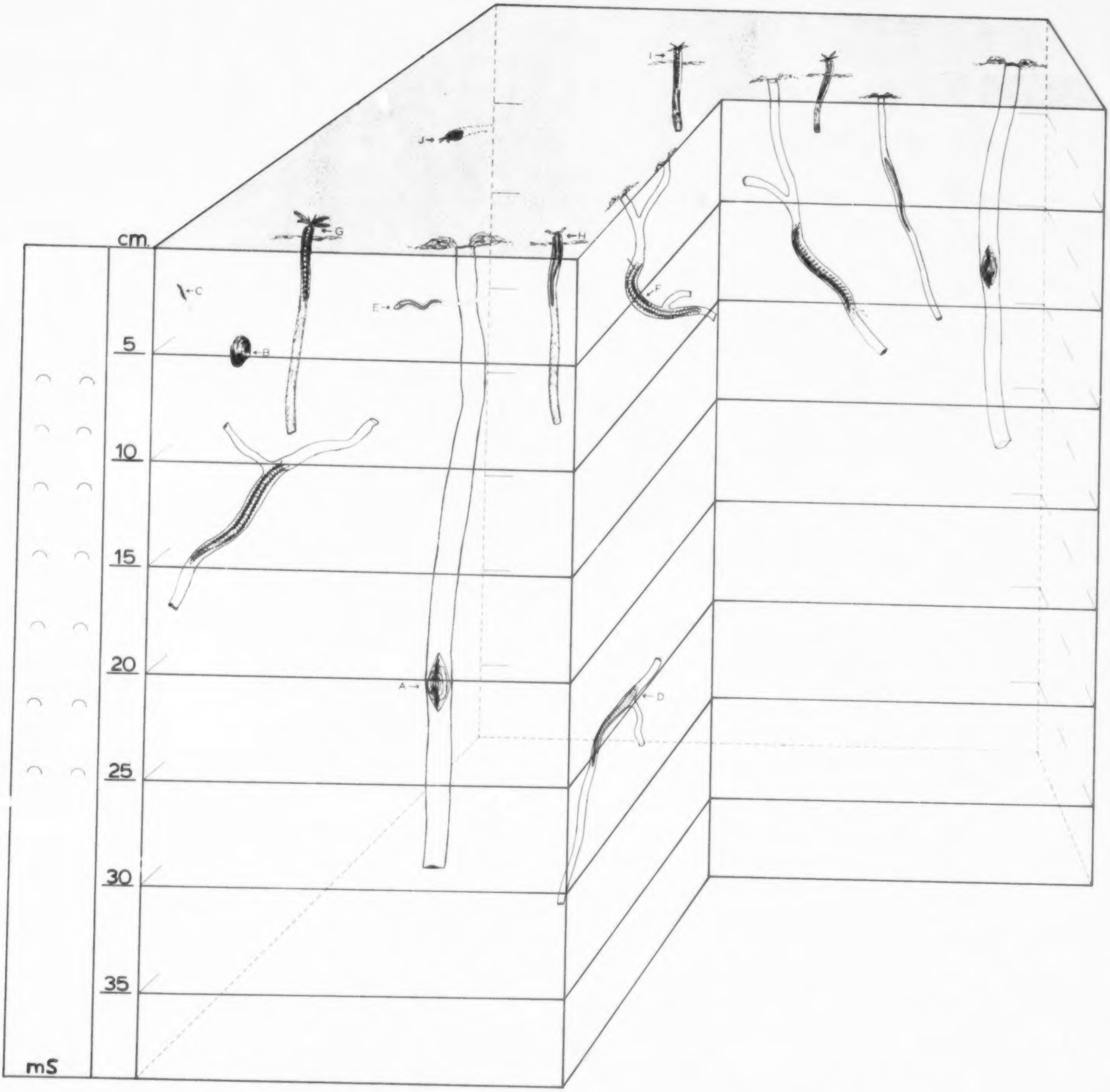
G. Paraprionspio pinnata

H. Scolecolepides viridis

I. Streblospio benedicti

J. Leptocheirus plumulosus

MD. 17



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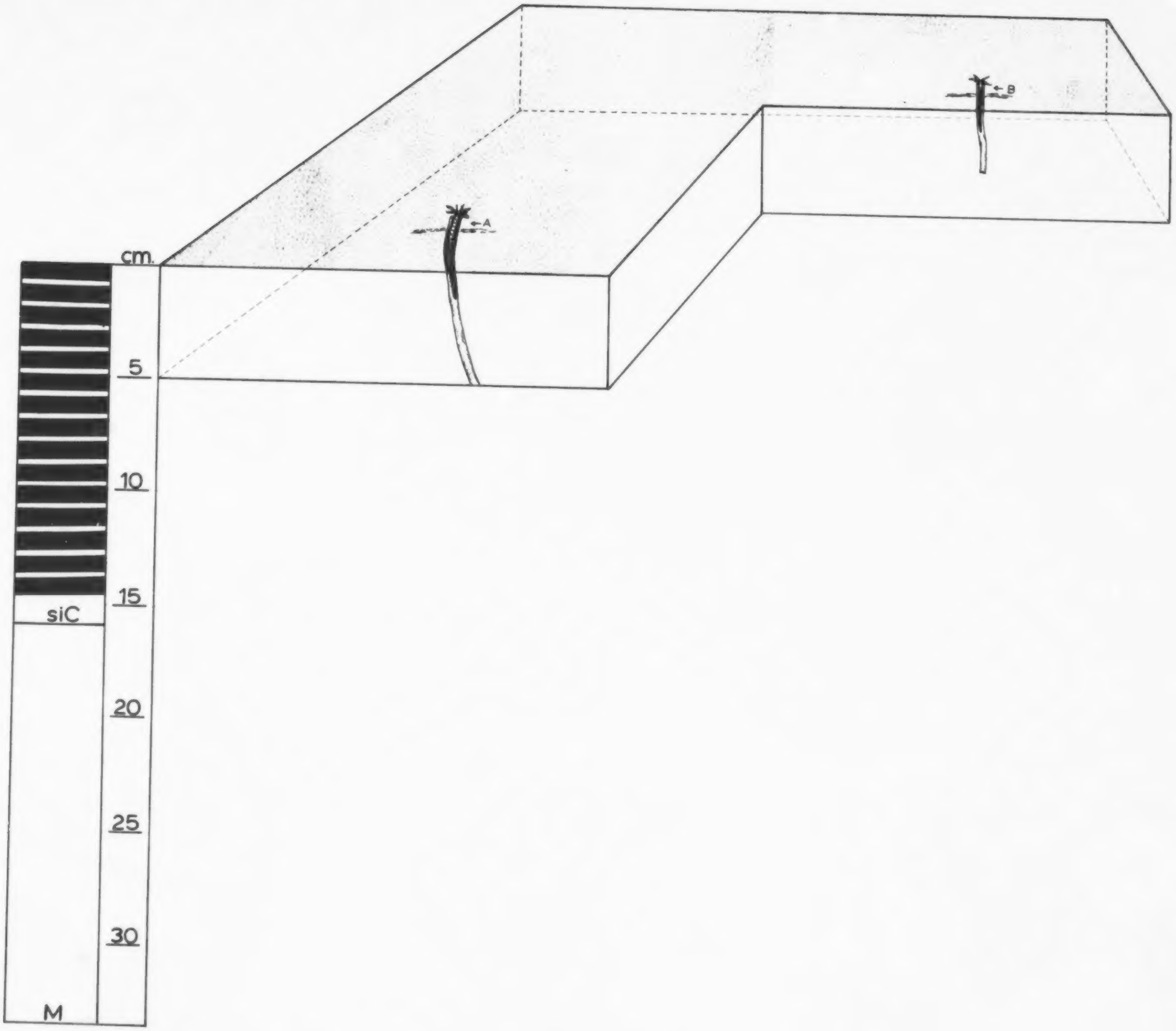
Station 18

(Fall 1978)

A. *Paraprionspio pinnata*

B. *Streblospio benedicti*

MD. 18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Station 19

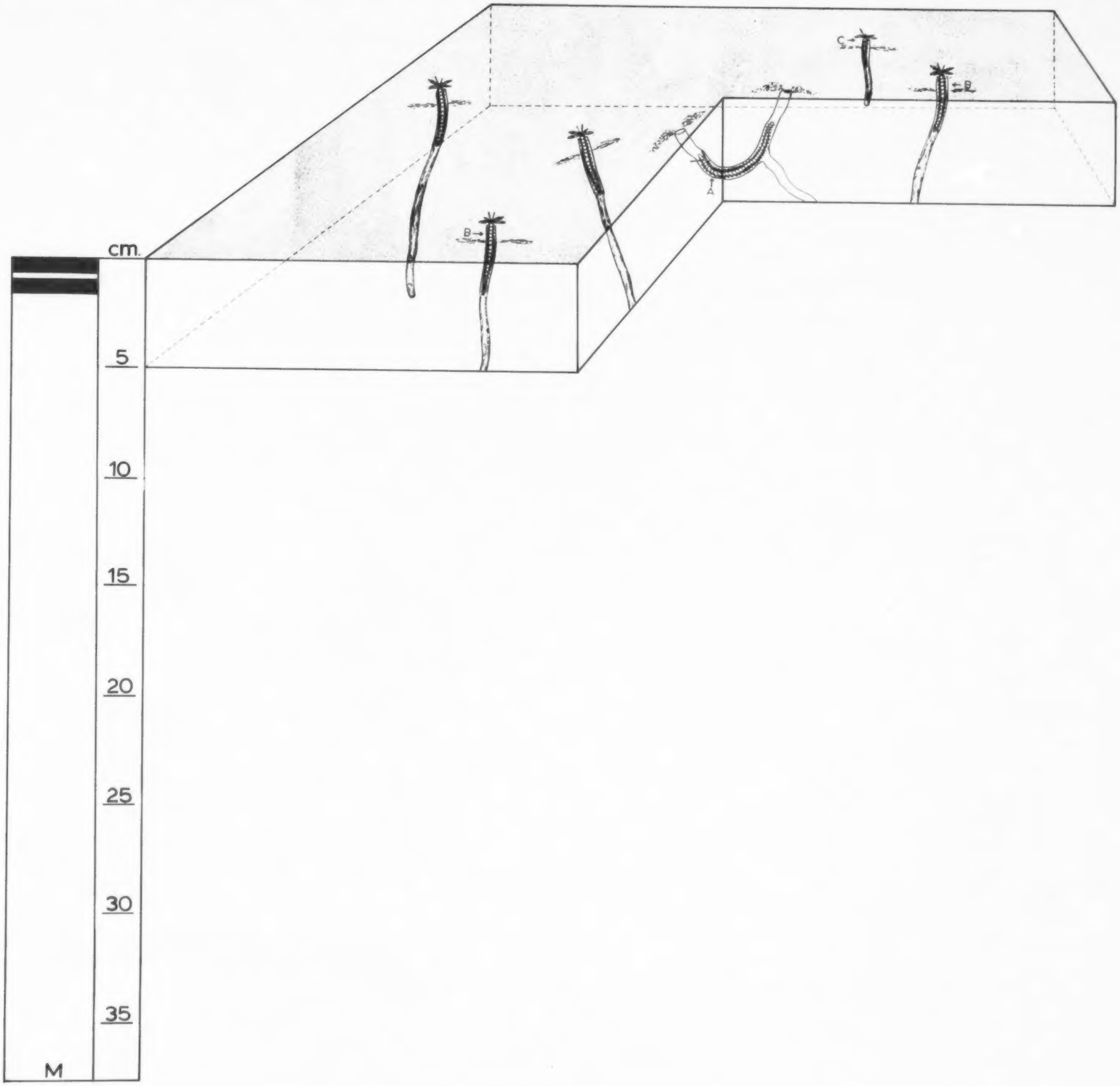
(Fall 1978)

A. _Nereis succinea_

B. _Paraprionspio pinnata_

C. _Streblospio benedicti_

MD. 19



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Station 20

(Fall 1978)

A. Oligochaete sp.

B. *Heteromastus filiformis*

C. *Tharyx setigera*

D. *Glycera dibranchiata*

E. *Glycinde solitaria*

F. *Nereis succinea*

G. *Scoloplos rubra*

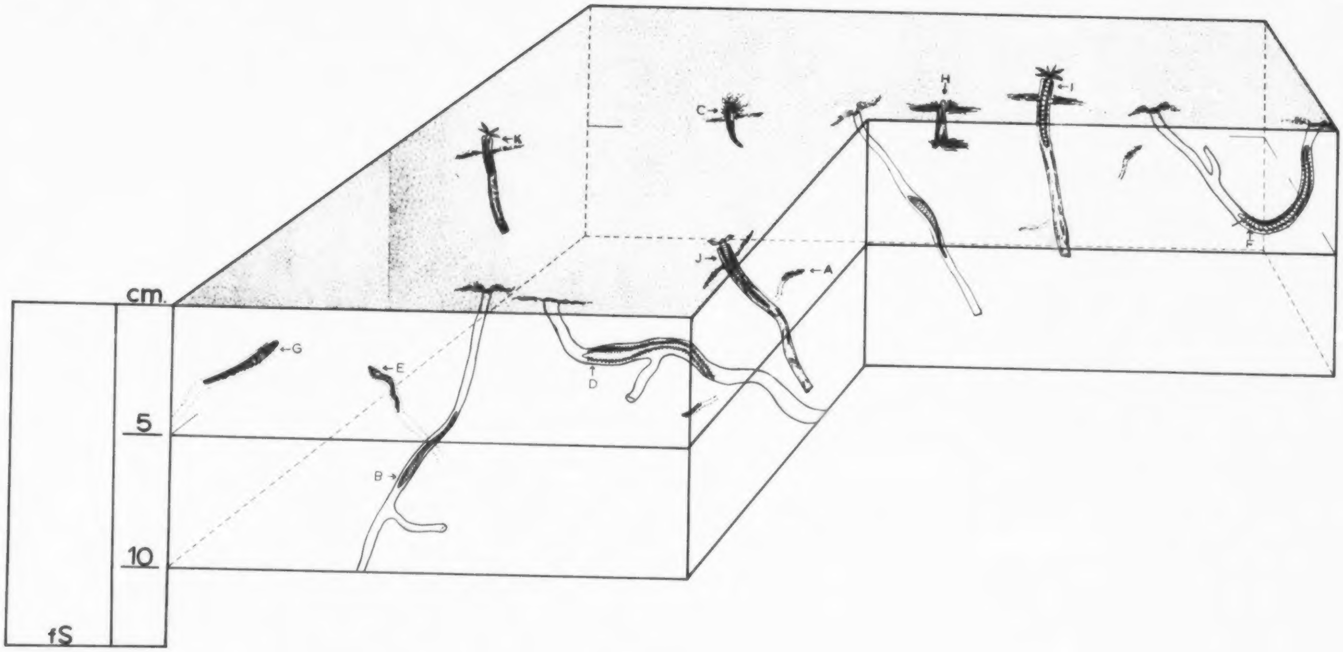
H. *Pectinaria gouldii*

I. *Paraprionspio pinnata*

J. *Scolecolepides viridis*

K. *Streblospio benedicti*

MD. 20


cm.
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Station 21

(Fall 1978)

A. Cerebratulus lacteus

B. Oligochaete sp.

C. Tharyx setigera

D. Glycera dibranchiata

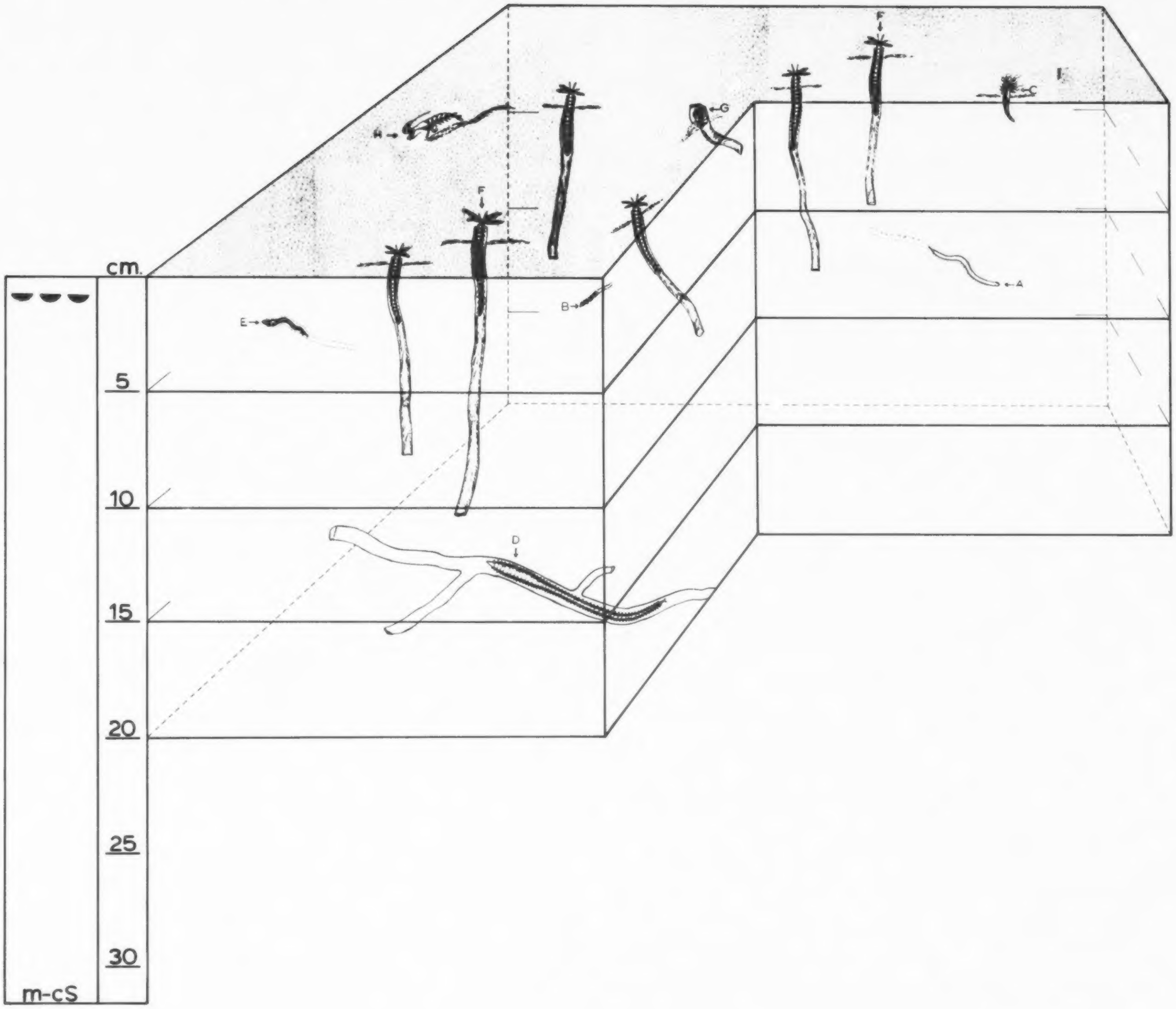
E. Glycinde solitaria

F. Paraprionspio pinnata

G. Ampelisca vadorum

H. Neomysis americana

MD. 21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Station 22

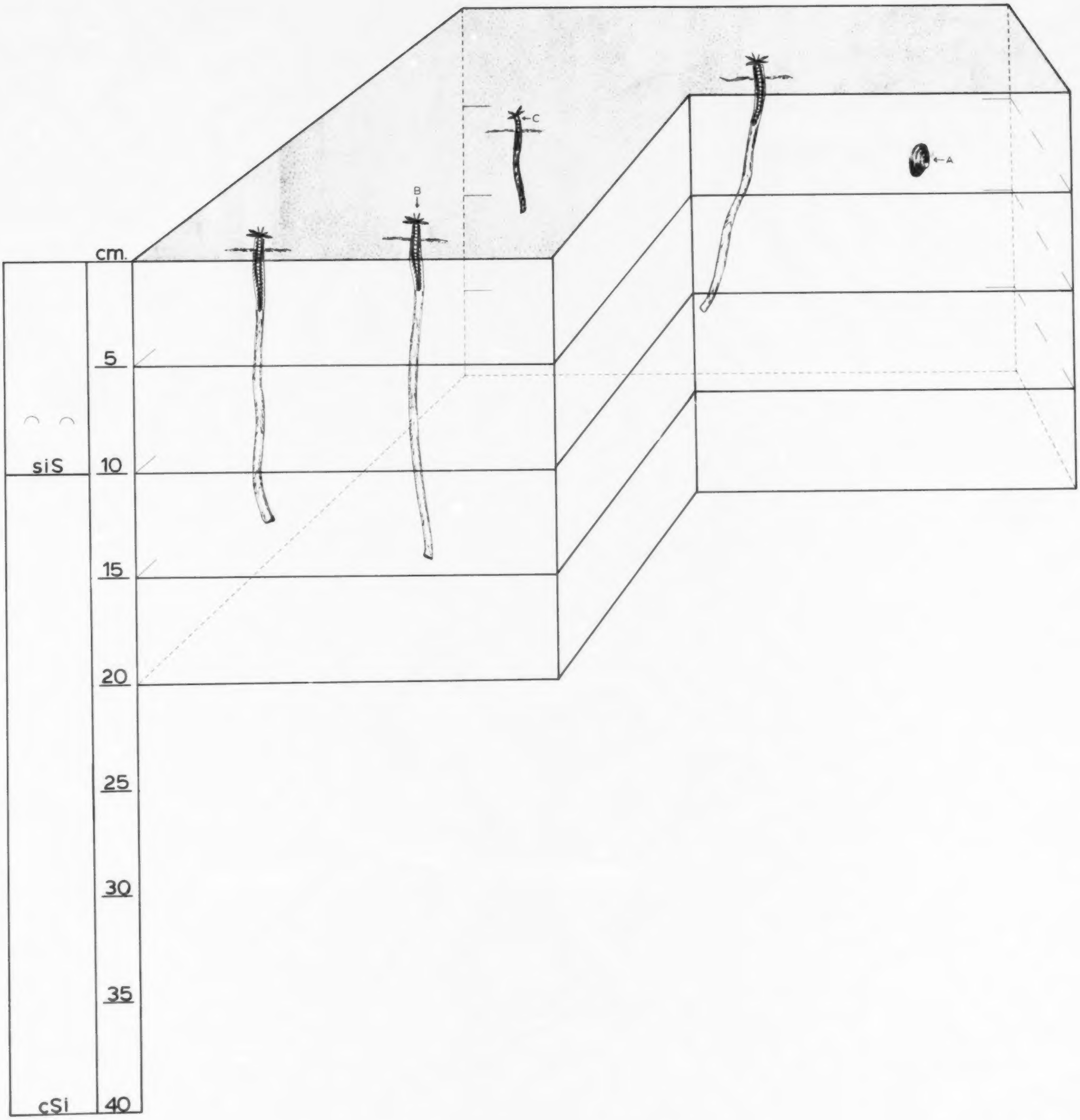
(Fall 1978)

A. *Macoma mitchelli*

B. *Paraprionspio pinnata*

C. *Streblospio benedicti*

MD. 22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Station 23

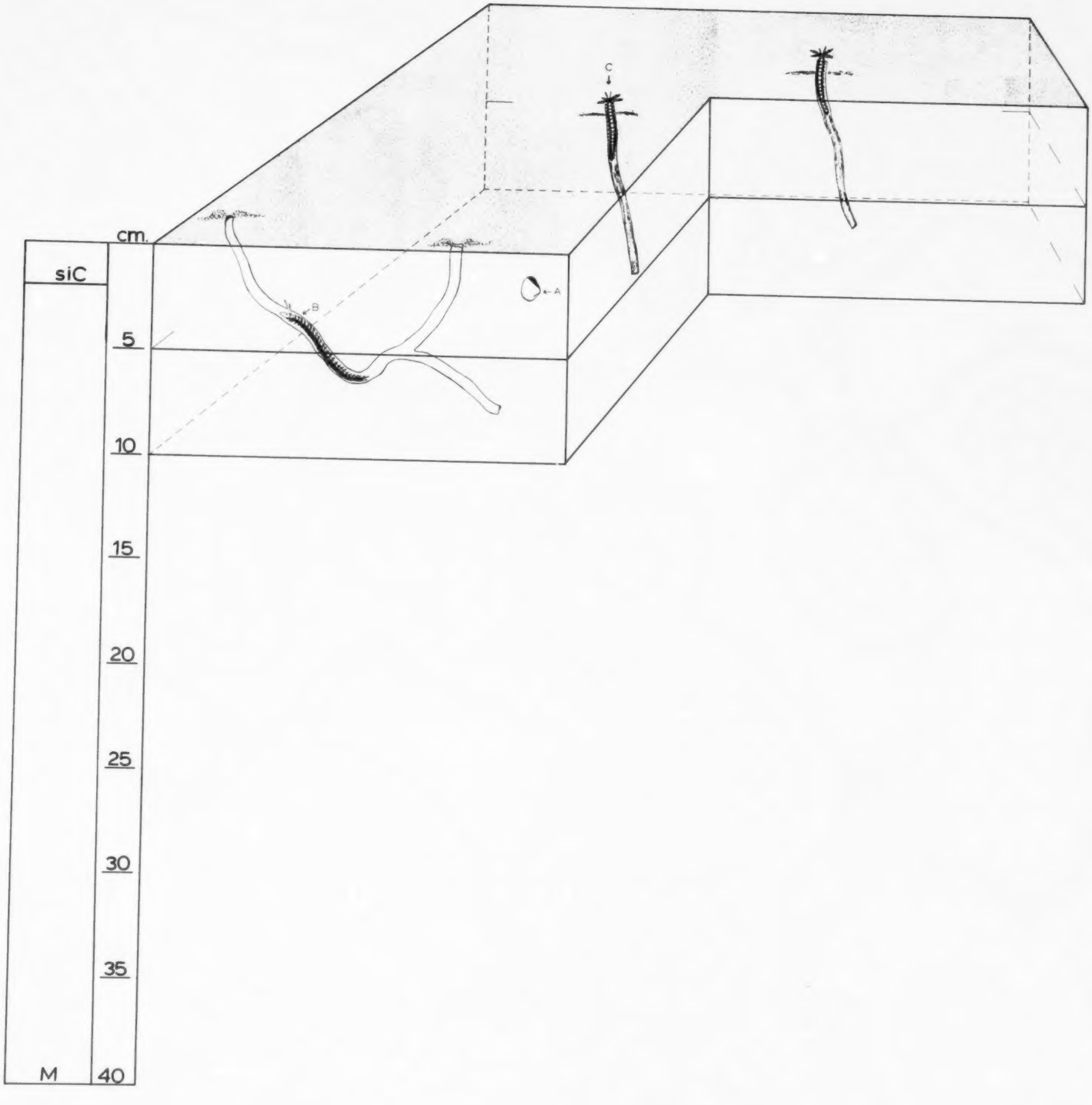
(Fall 1978)

A. *Mulinia lateralis*

B. *Nereis succinea*

C. *Paraprionspio pinnata*

MD. 23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Station 24

(Fall 1978)

A. *Glycinde solitaria*

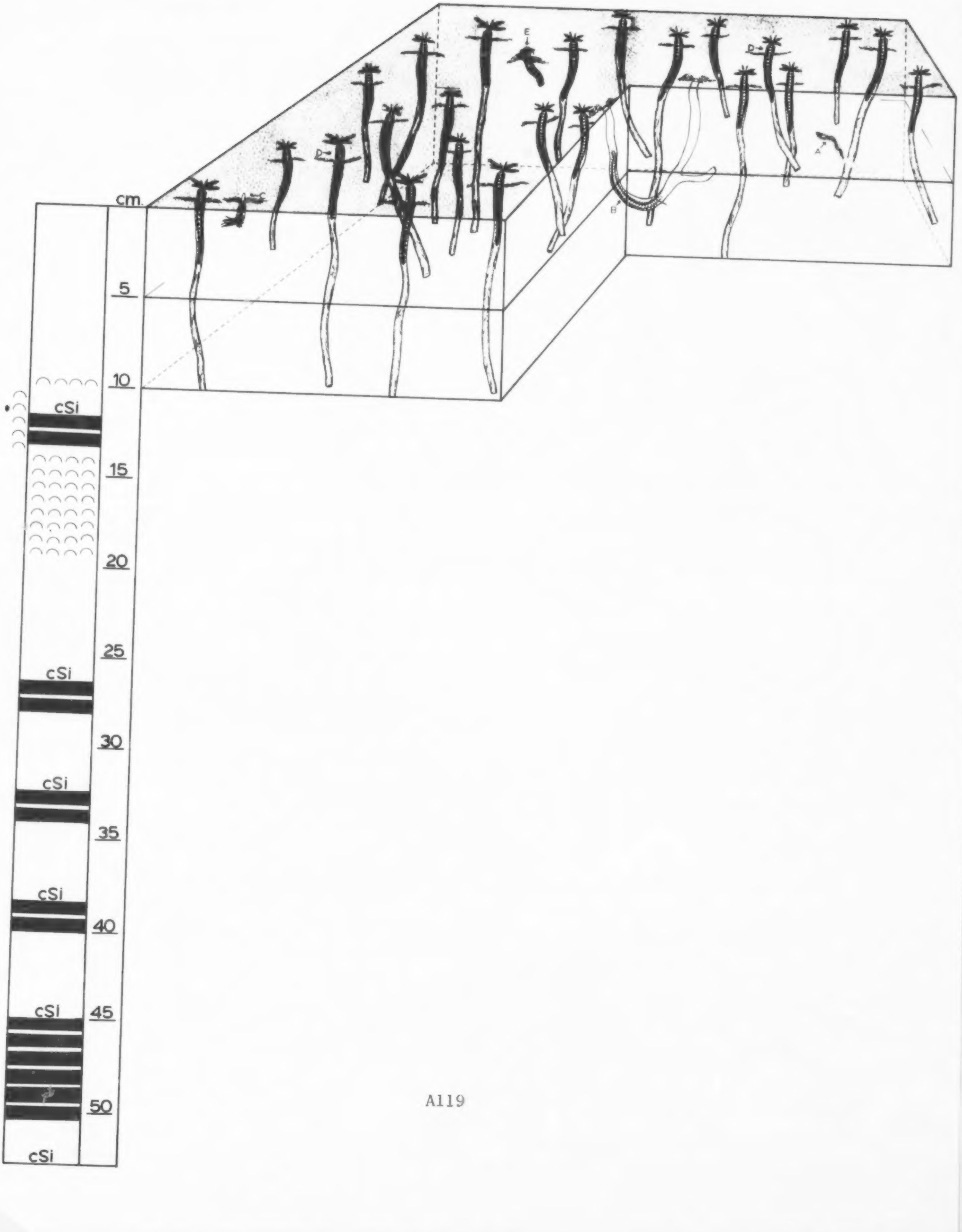
B. *Nereis succinea*

C. *Pectinaria gouldii*

D. *Paraprionspio pinnata*

E. *Ampelisca abdita*

MD. 24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Station 25

(Fall 1978)

A. *Phoronis* sp.

B. *Retusa canaliculata*

C. *Lucina multilineata*

D. *Mulinia lateralis*

E. *Pseudeurythoe ambigua*

F. *Heteromastus filiformis*

G. *Glycera dibranchiata*

H. *Glycinde solitaria*

I. *Scoloplos rubra*

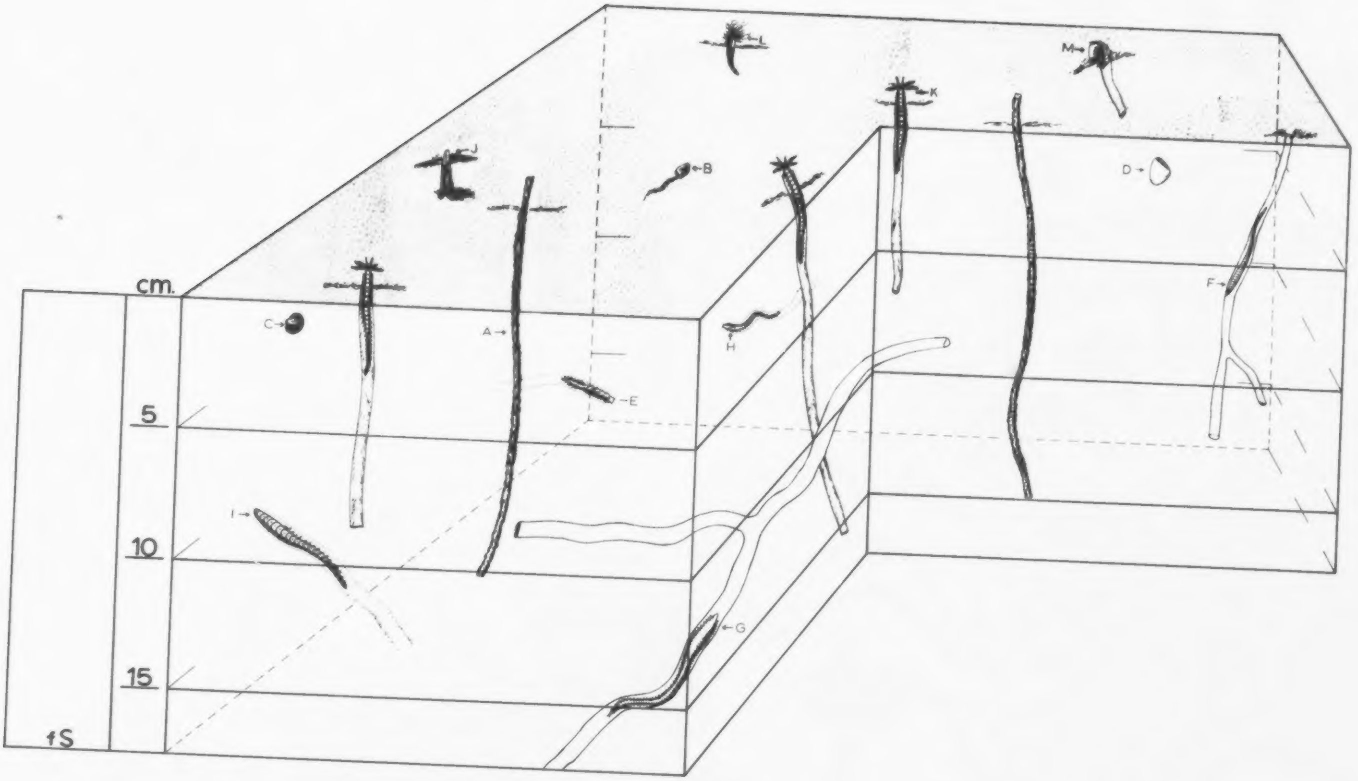
J. *Pectinaria gouldii*

K. *Paraprionspio pinnata*

L. *Pista palmata*

M. *Ampelisca vadorum*

MD. 25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Station 1

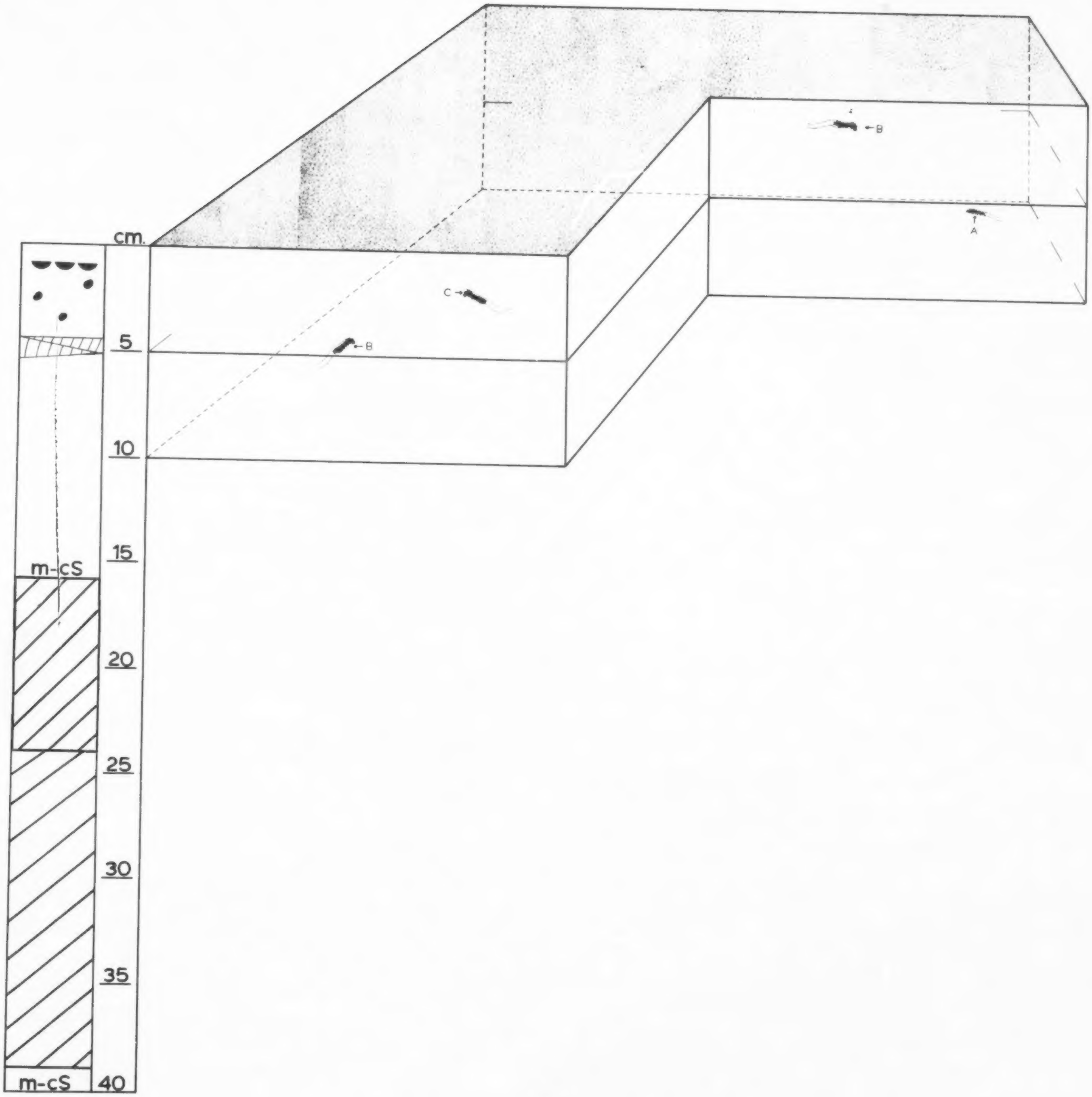
(Summer 1979)

A. Oligochaete sp.

B. _Chironomus_ sp.

C. _Cryptochrionomus_ sp.

MD. 1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Station 2

(Summer 1979)

A. *Pisidium* sp.

B. Oligochaete sp.

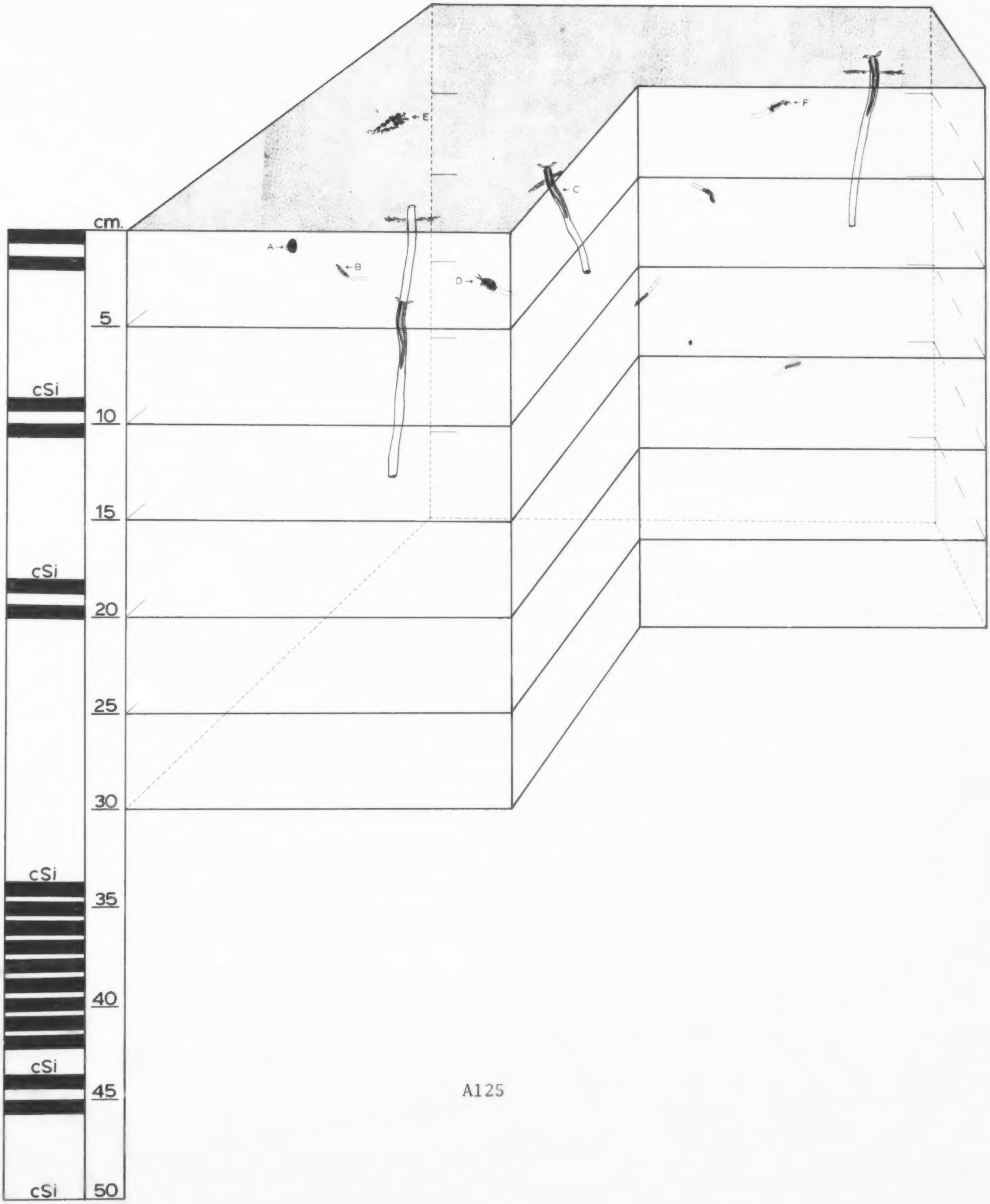
C. *Scolecolepides viridis*

D. *Leptocheirus plumulosus*

E. *Chirodotea caeca*

F. *Clinotanypus* sp.

MD. 2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Station 6

(Summer 1979)

A. Nemertean sp.

B. *Rangia cuneata*

C. *Macoma balthica*

D. Oligochaete sp.

E. *Heteromastus filiformis*

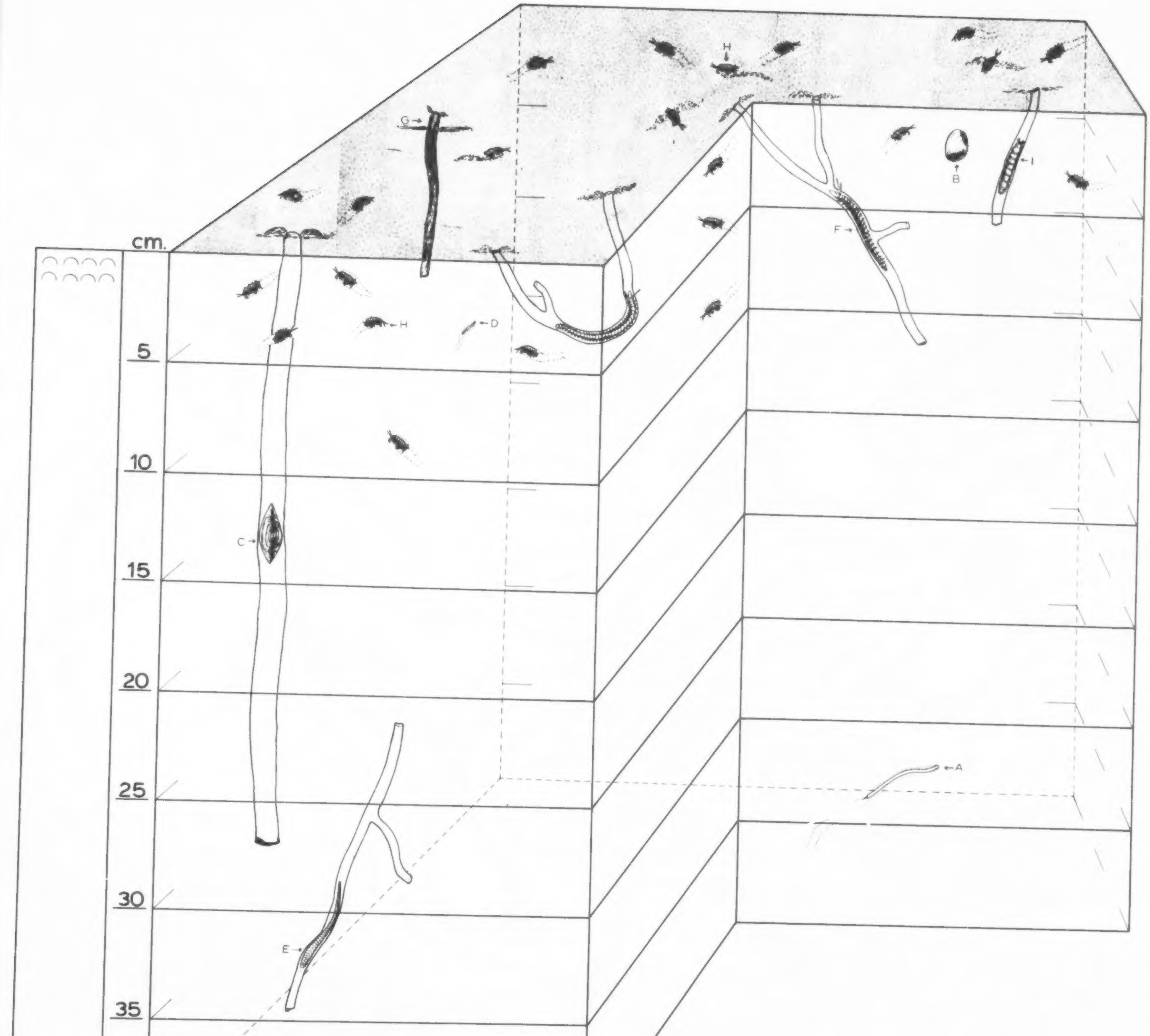
F. *Nereis succinea*

G. *Scolecolepides viridis*

H. *Leptocheirus plumulosus*

I. *Cyathura polita*

MD. 6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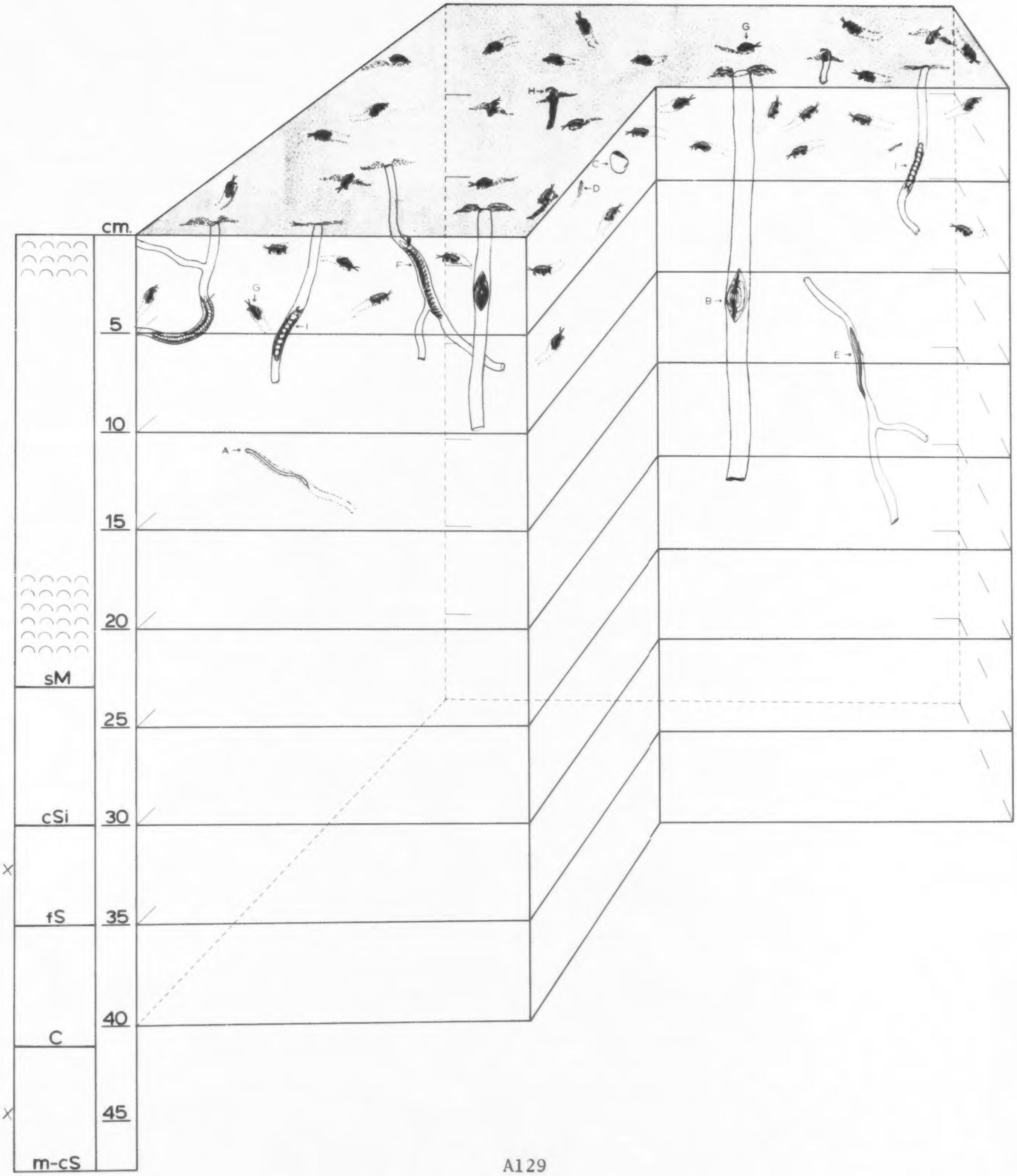
Station 7

(Summer 1979)

A. Nemertean sp.
B. *Macoma balthica*
C. *Mulinia lateralis*
D. Oligochaete sp.
E. *Heteromastus filiformis*
G. *Leptocheirus plumulosus*
H. *Corophium lacustre*
I. *Cyathura polita*

MD. 7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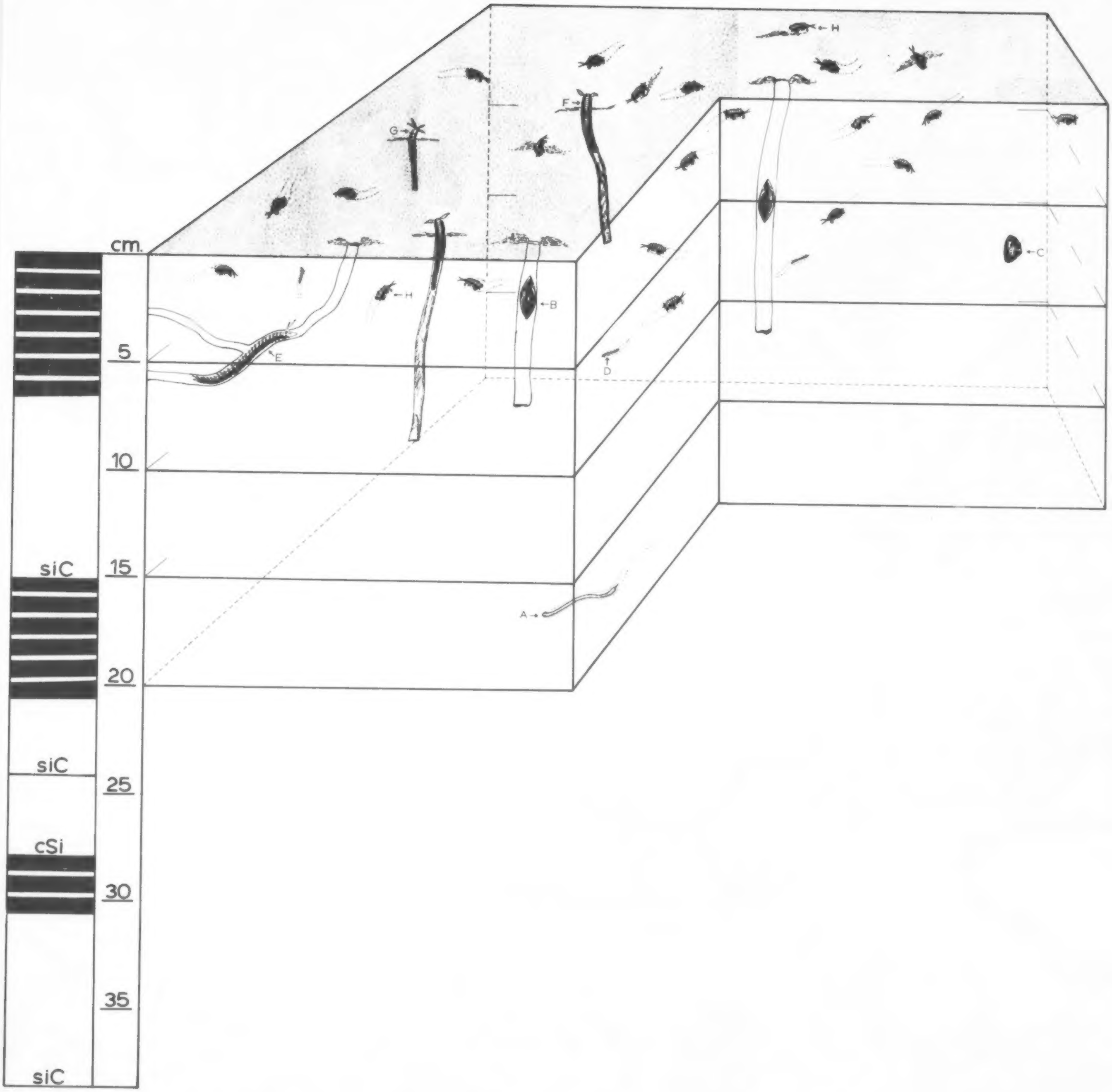
Station 8

(Summer 1979)

A. Nemertean sp.
B. *Macoma balthica*
C. *Macoma mitchelli*
D. Oligochaete sp.
E. *Nereis succinea*
F. *Scolecolepides viridis*
G. *Streblospio benedicti*
H. *Leptocheirus plumulosus*

MD. 8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A

Station 13

(Summer 1979)

A. Nemertean sp.

B. *Mulinia lateralis*

C. *Macoma balthica*

D. *Macoma mitchelli*

E. Oligochaete sp.

F. *Heteromastus filiformis*

G. *Nereis succinea*

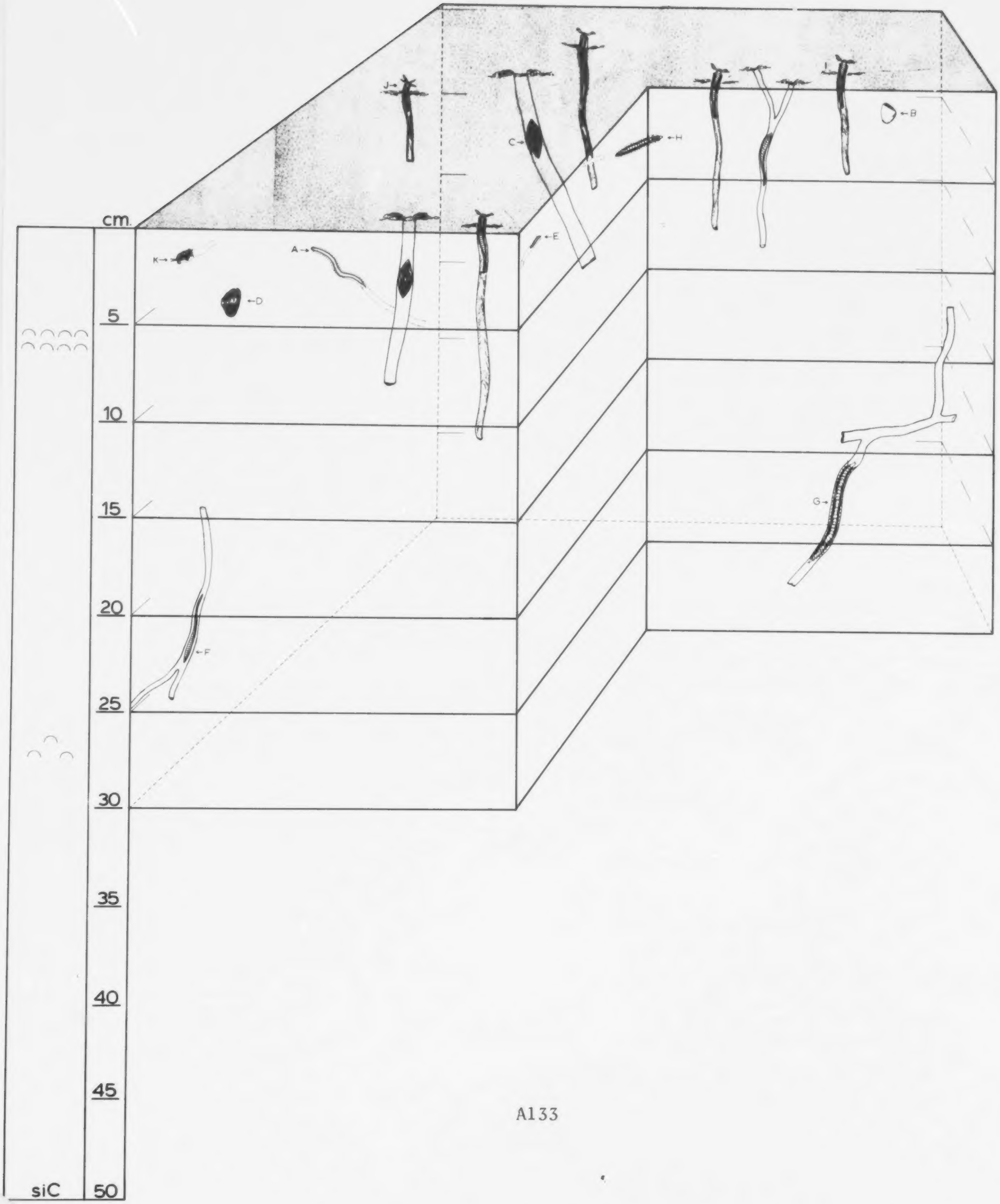
H. *Eteone heteropoda*

I. *Scolecolepides viridis*

J. *Streblospio benedicti*

K. *Leptocheirus plumulosus*

MD. 13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Station 14

(Summer 1979)

A. *Mulinia lateralis*

B. *Macoma balthica*

C. *Macoma mitchelli*

D. Oligochaete sp.

E. *Nereis succinea*

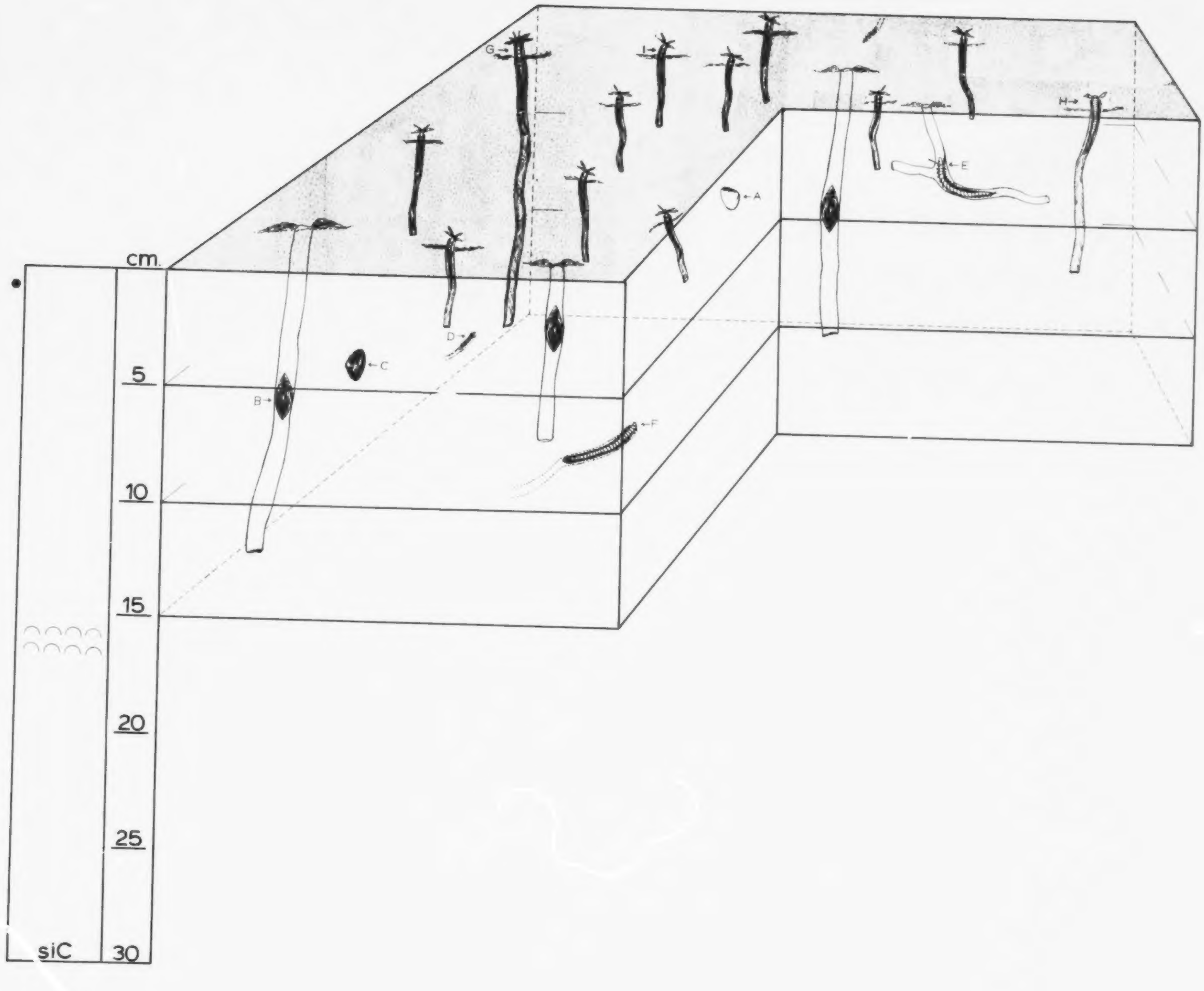
F. *Eteone heteropoda*

G. *Paraprionspio pinnata*

H. *Scolecolepides viridis*

I. *Streblospio benedicti*

MD. 14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Station 15

(Summer 1979)

A. Nemertean sp.

B. Macoma balthica

C. Macoma mitchelli

D. Oligochaete sp.

E. Heteromastus filiformis

F. Nereis succinea

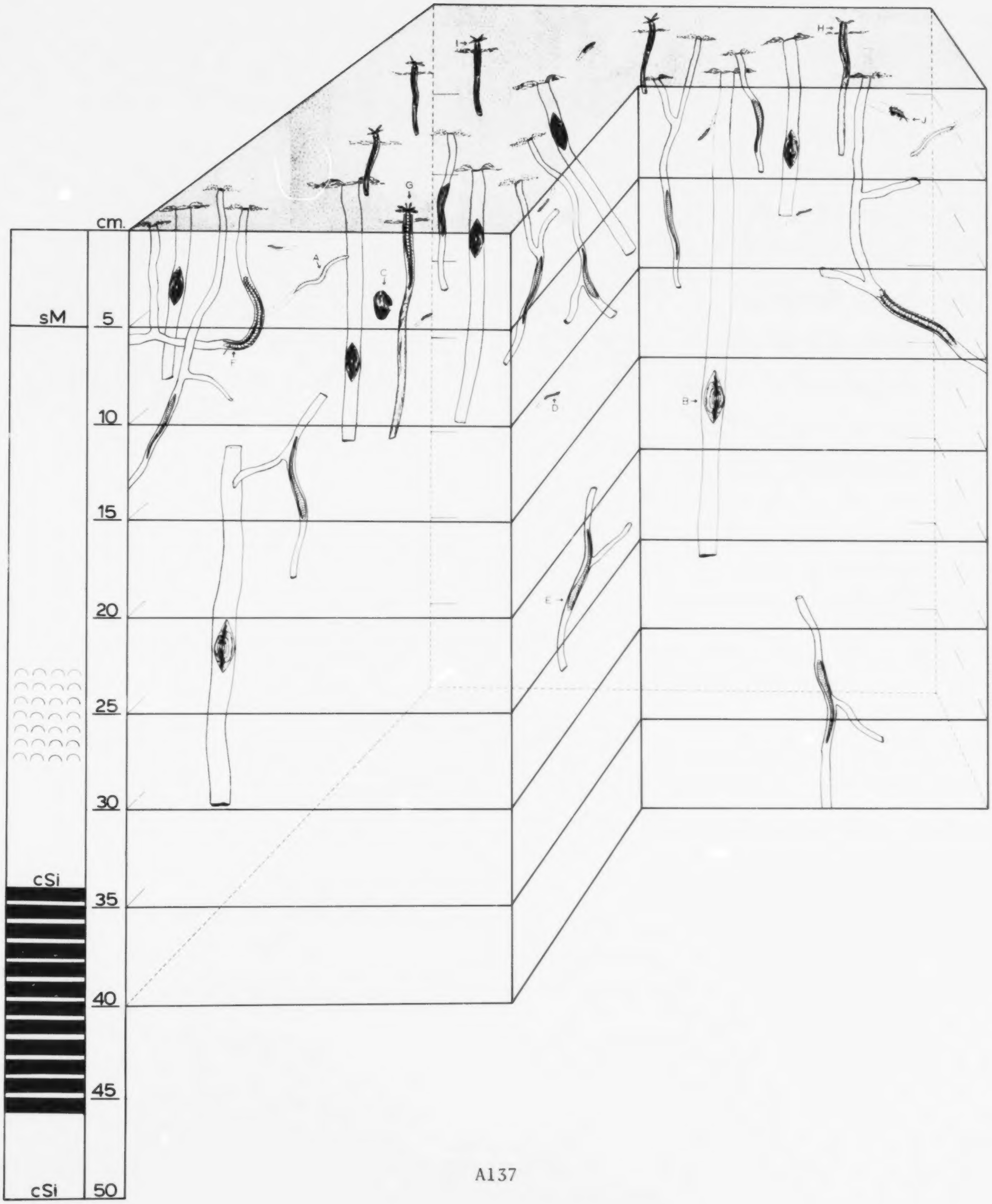
G. Paraprionspio pinnata

H. Scolecolepides viridis

I. Streblospio benedicti

J. Leptocheirus plumulosus

MD. 15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Station 21

(Summer 1979)

A. Nemertean sp.

B. Lyonsia hyalina

C. Mulinia lateralis

D. Macoma balthica

E. Macoma mitchelli

F. Oligochaete sp.

G. Heteromastus filiformis

H. Glycera dibranchiata

I. Glycinde solitaria

J. Nereis succinea

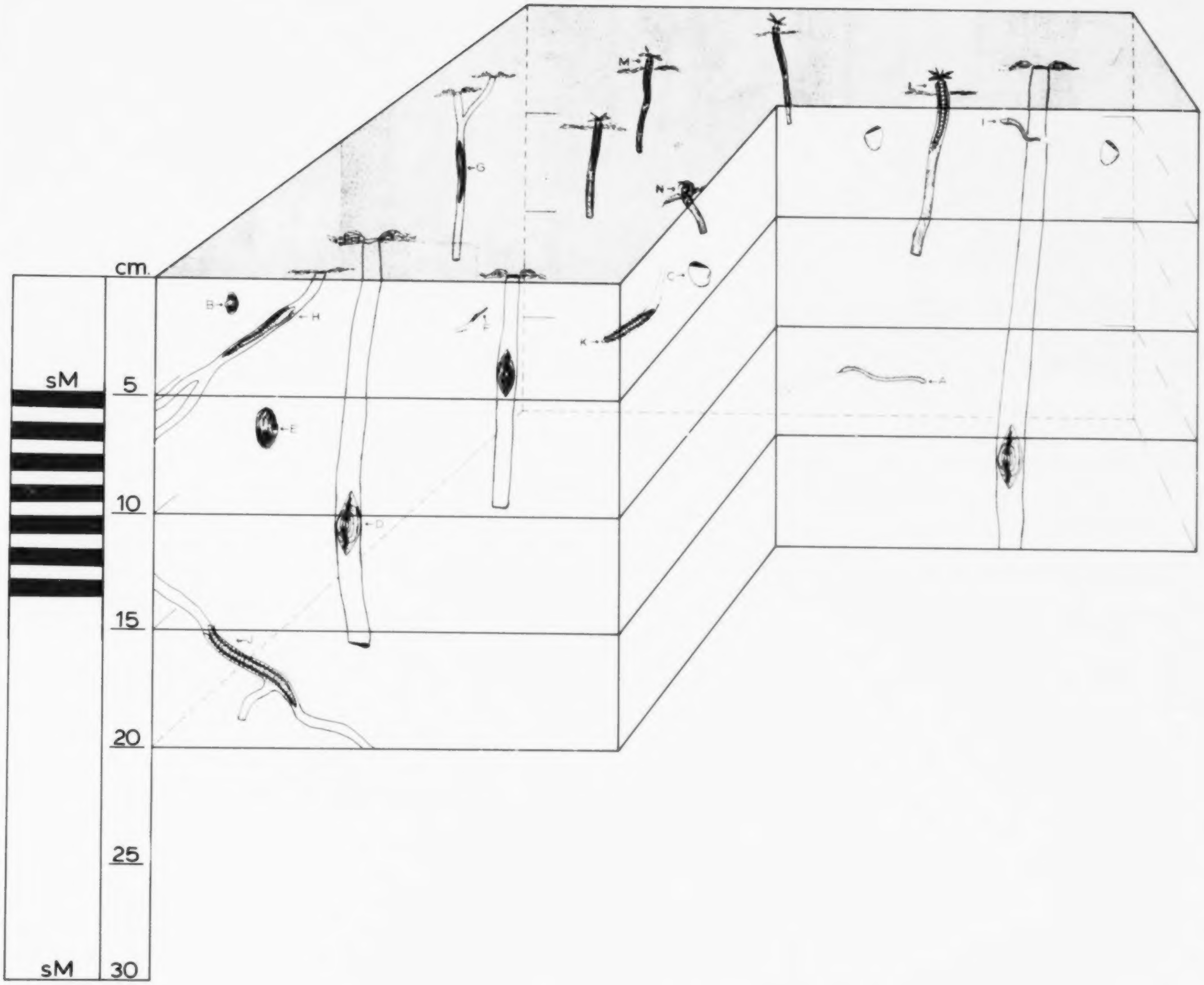
K. Eteone heteropoda

L. Paraprionspio pinnata

M. Streblospio benedicti

N. Ampelisca abdita

MD. 21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Station 23

(Summer 1979)

A. Nemertean sp.

B. Mulinia lateralis

C. Macoma balthica

D. Heteromastus filiformis

E. Glycera dibranchiata

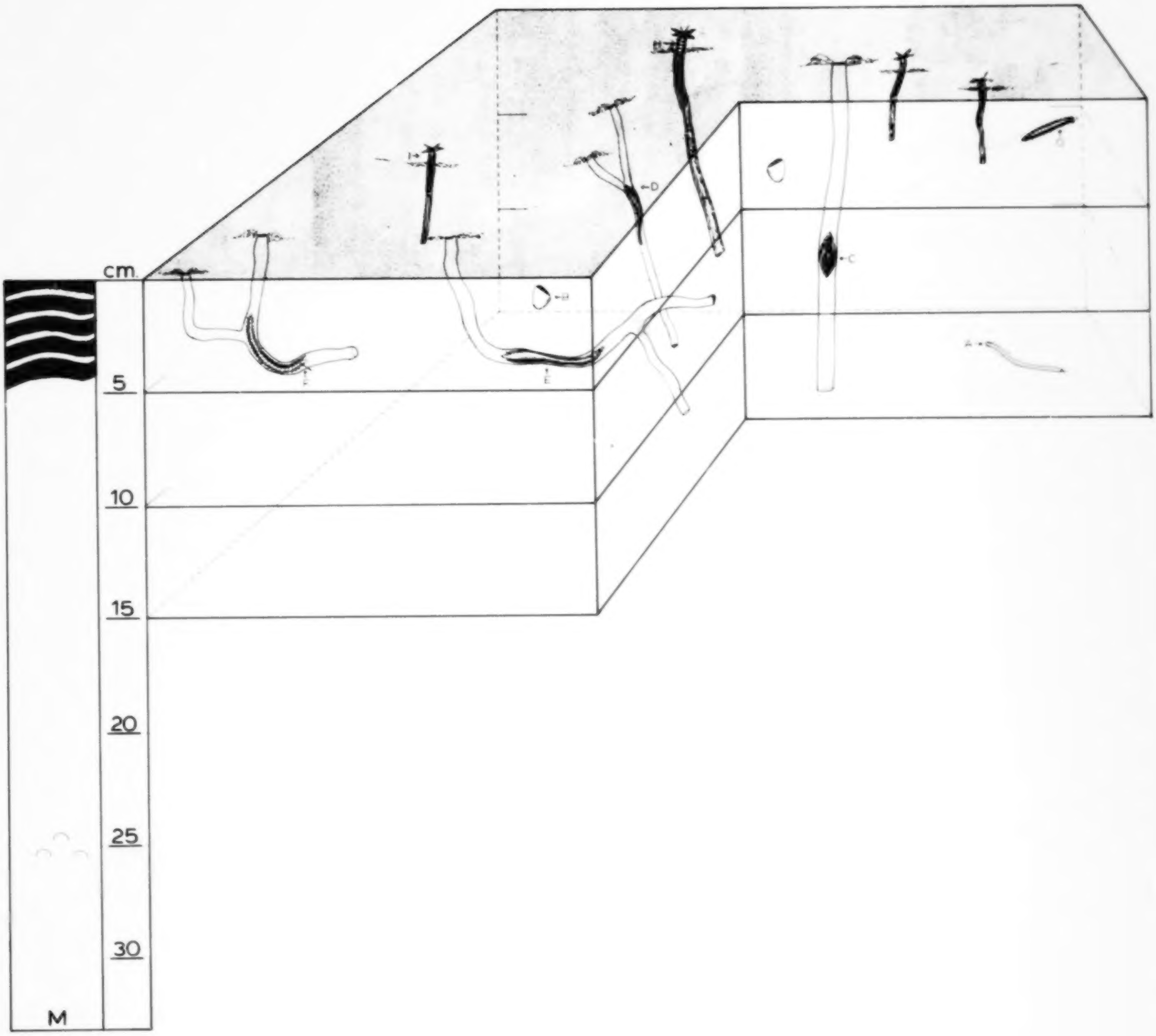
F. Nereis succinea

G. Eteone heteropoda

H. Paraprionspio pinnata

I. Streblospio benedicti

MD 23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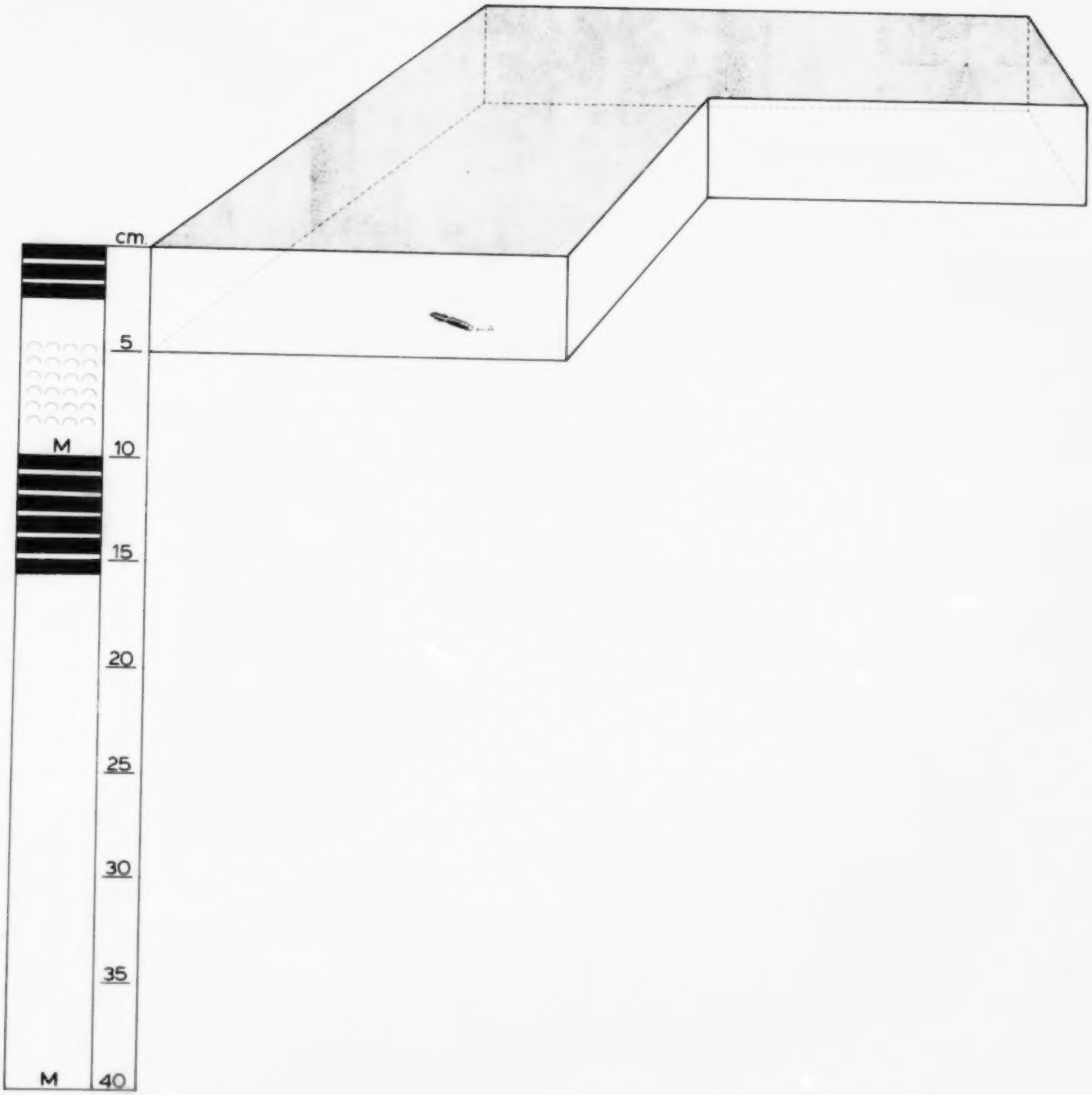
Station 24

(Summer 1979)

A. *Pseudeurythoe ambigua*

MD. 24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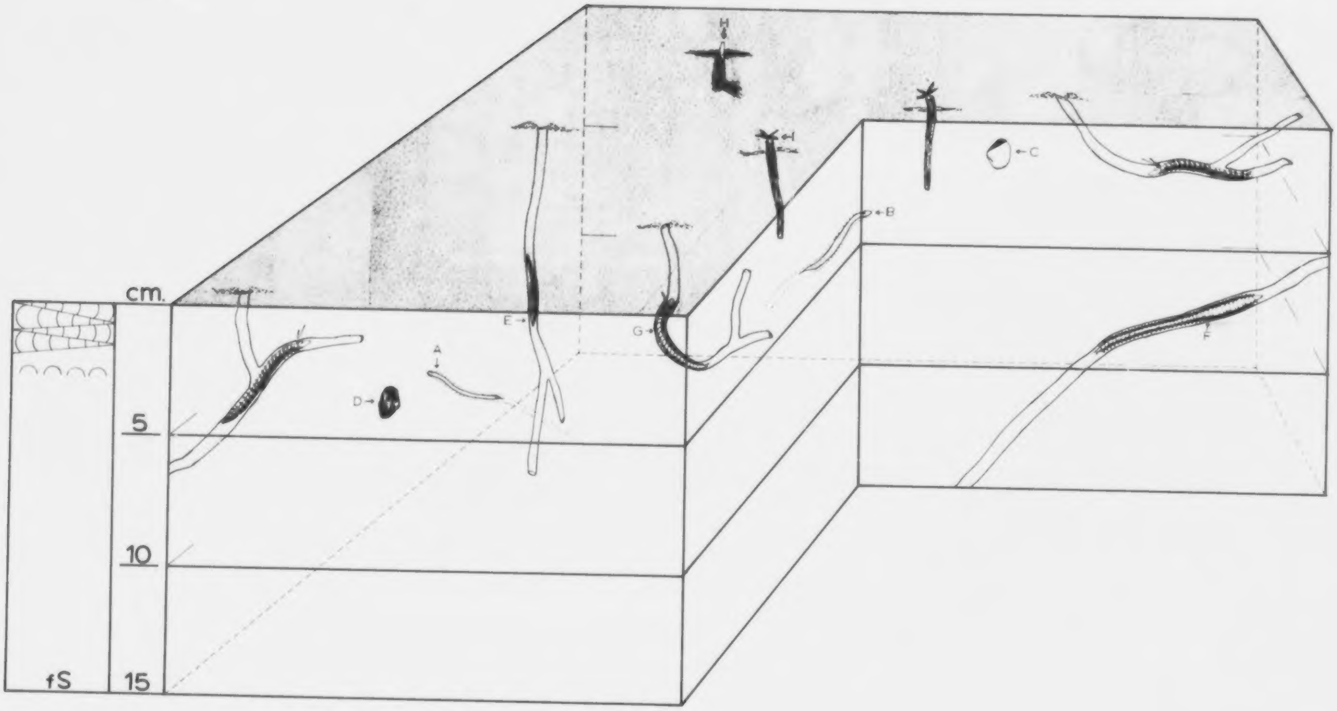
Station 25

(Summer 1979)

A. Nemertean sp.
B. *Cerebratulus lacteus*
C. *Mulinia lateralis*
D. *Macoma mitchelli*
E. *Heteromastus filiformis*
F. *Glycera dibranchiata*
G. *Nereis succinea*
H. *Pectinaria gouldii*
I. *Streblospio benedicti*

MD. 25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Station 51

(Summer 1979)

A. Oligochaete sp.

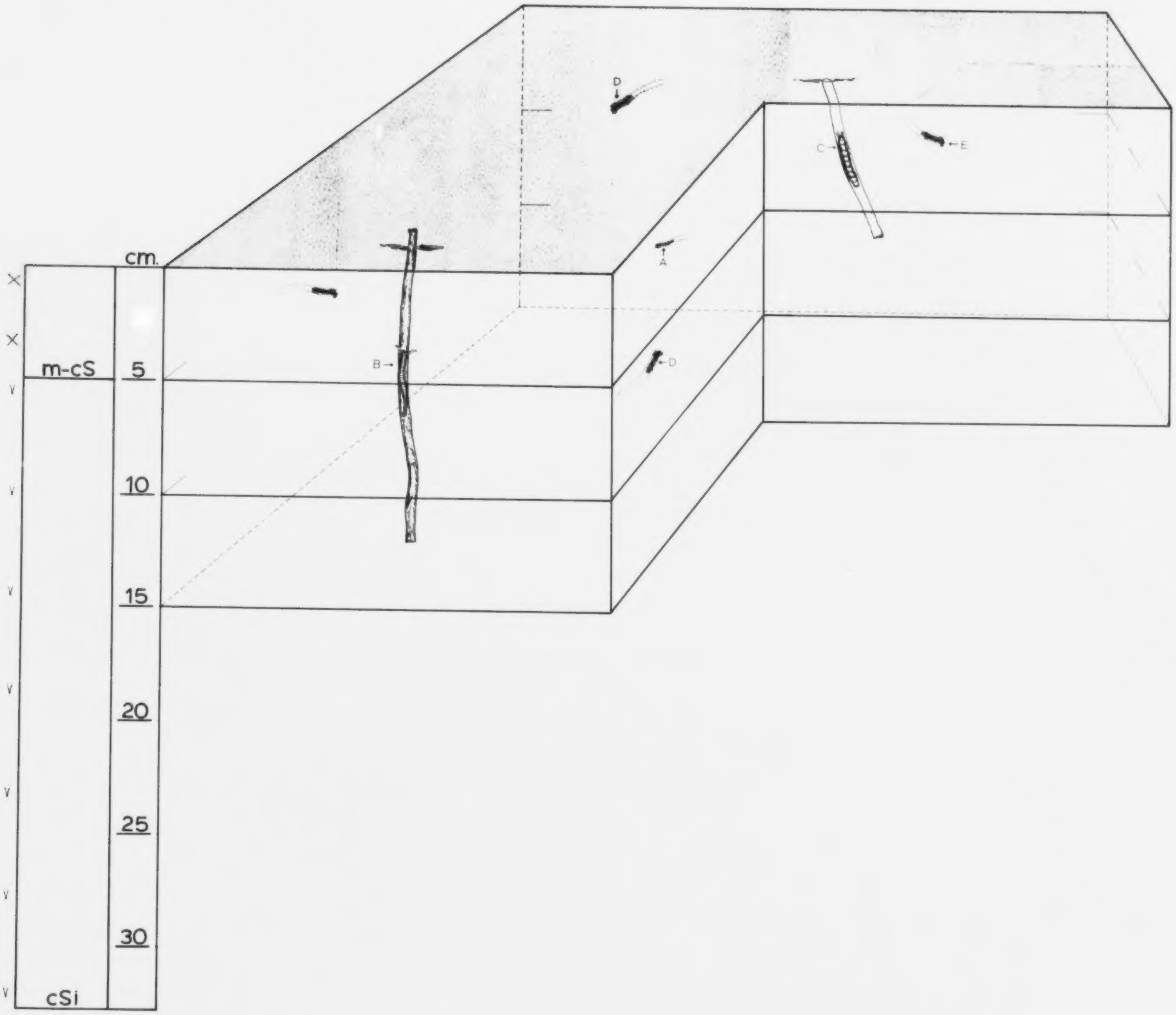
B. *Scolecolepides viridis*

C. *Cyathura polita*

D. *Chironomus* sp.

E. *Cryptochironomus* sp.

MD. 51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Station 52

(Summer 1979)

A. *Cerebratulus lacteus*

B. *Rangia cuneata*

C. Oligochaete sp.

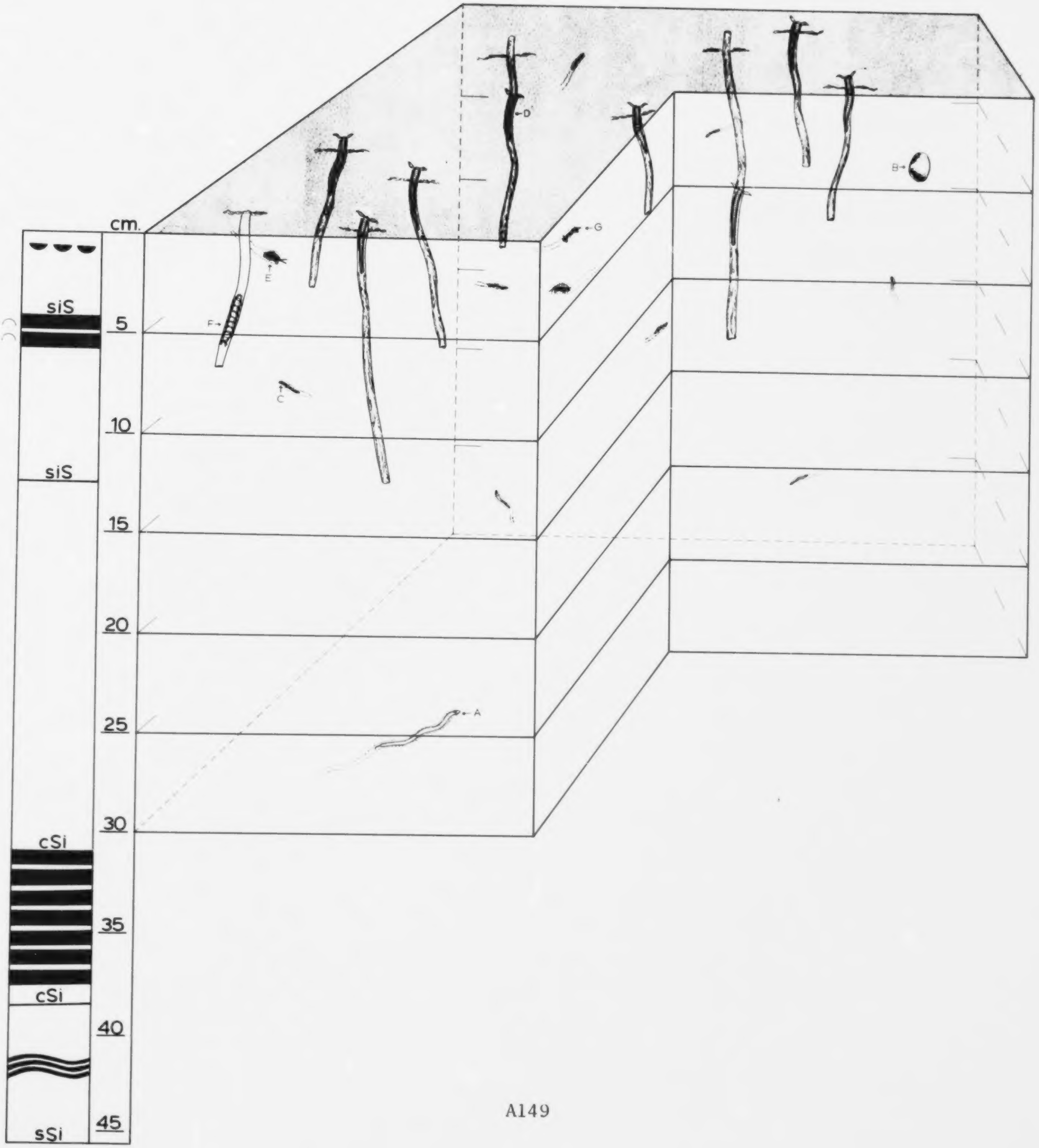
D. *Scolecolepides viridis*

E. *Leptocheirus plumulosus*

F. *Cyathura polita*

G. *Procladius* sp.

MD. 52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Station 53

(Summer 1979)

A. Oligochaete sp.

B. Heteromastus filiformis

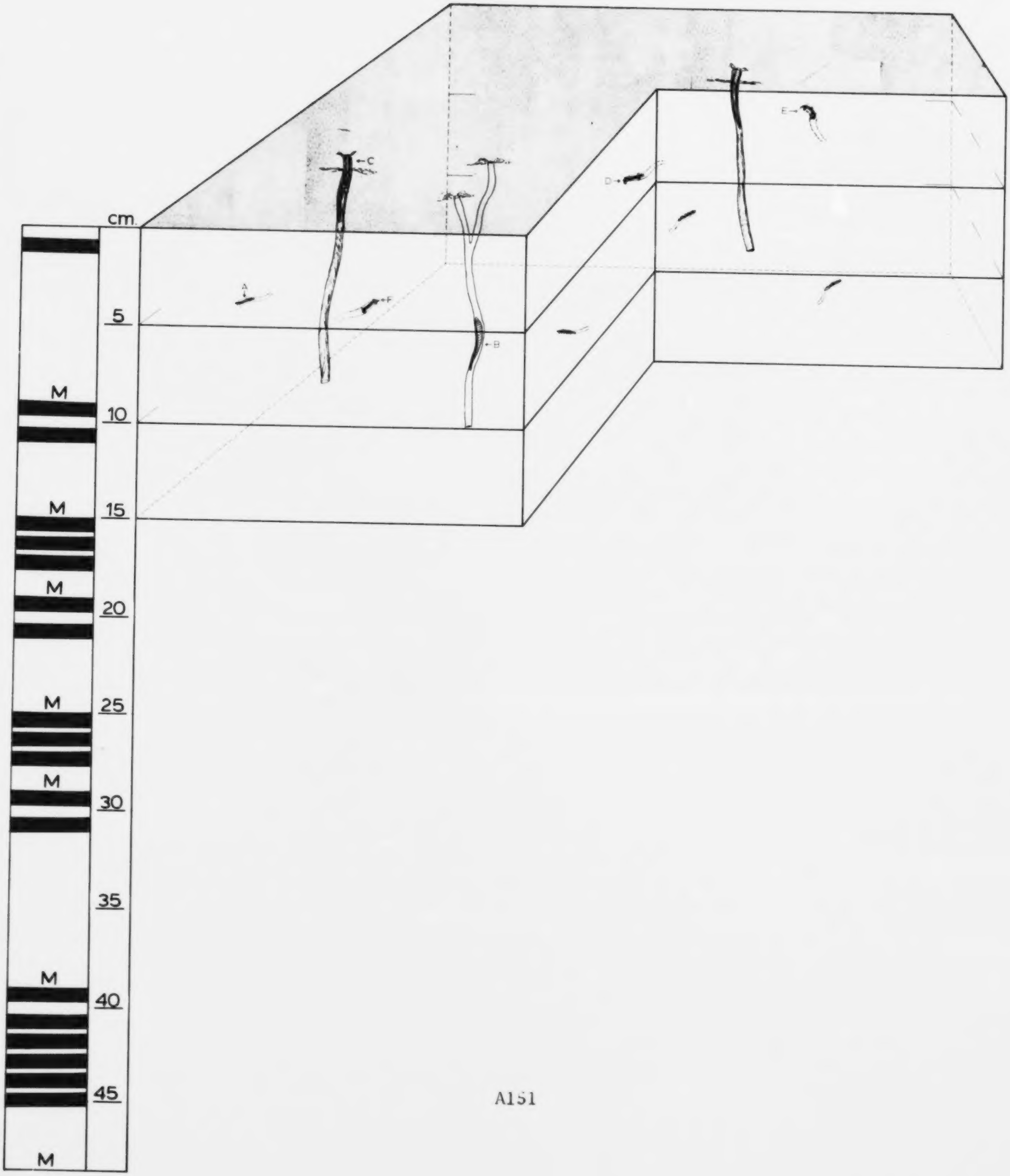
C. Scolecolepides viridis

D. Chironomus sp.

E. Coelotanypus sp.

F. Procladius sp.

MD. 53



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Station 54

(Summer 1979)

A. Nemertean sp.

B. *Mulinia lateralis*

C. *Mya arenaria*

D. *Macoma balthica*

E. *Macoma mitchelli*

F. Oligochaete sp.

G. *Heteromastus filiformis*

H. *Nereis succinea*

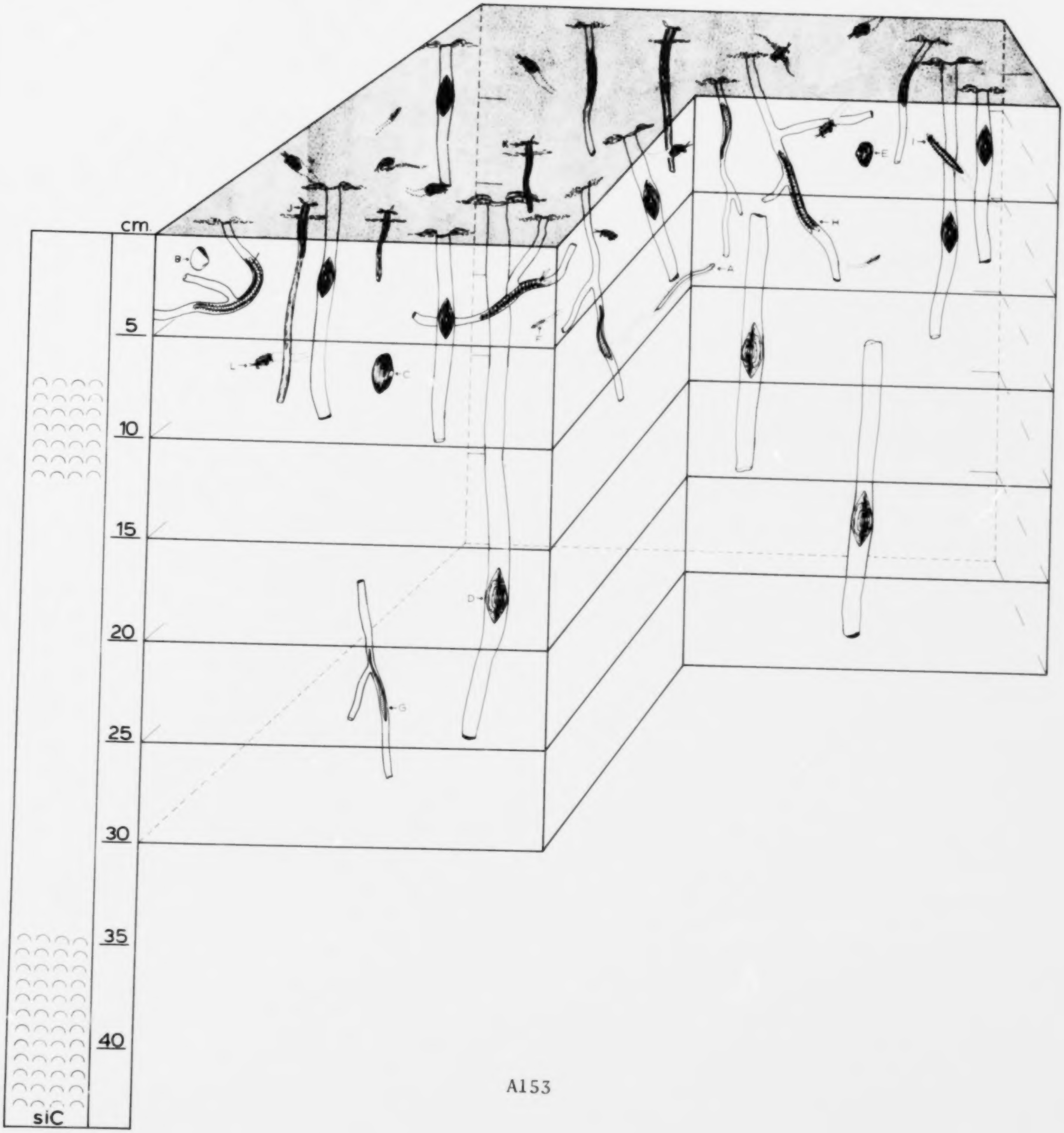
I. *Eteone heteropoda*

J. *Scolecolepides viridis*

K. *Streblospio benedicti*

L. *Leptocheirus plumulosus*

MD. 54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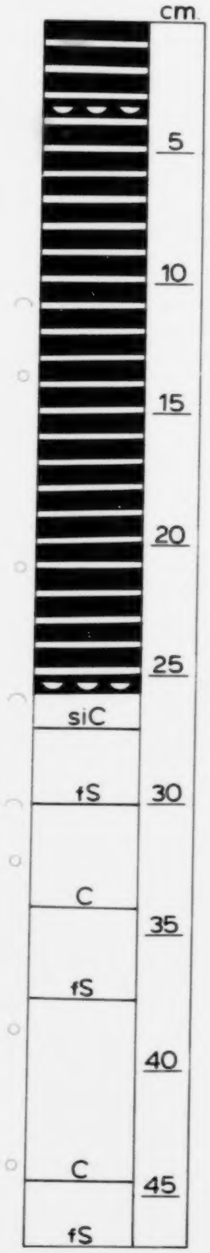
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Station 56

(Summer 1979)

A. Nemertean sp.

B. *Mulinia lateralis*

C. *Macoma balthica*

D. *Glycinde solitaria*

E. *Nereis succinea*

F. *Pectinaria gouldii*

G. *Eteone heteropoda*

H. *Paraprionspio pinnata*

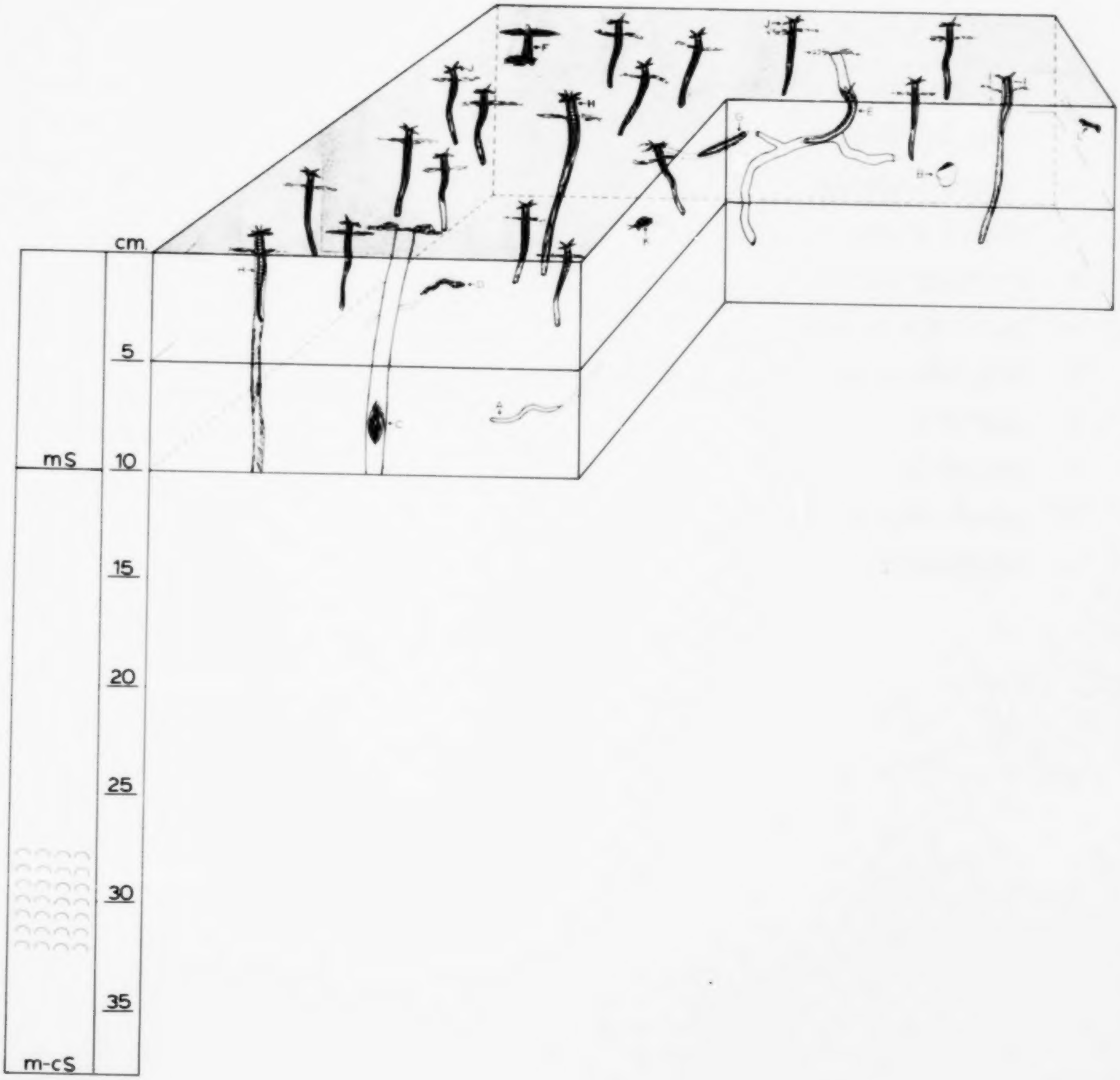
I. *Scolecolepides viridis*

J. *Streblospio benedicti*

K. *Leptocheirus plumulosus*

L. *Chironomus* sp.

MD 56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Station 57

(Summer 1979)

A. Mulinia lateralis

B. Macoma balthica

C. Glycera dibranchiata

D. Glycinde solitaria

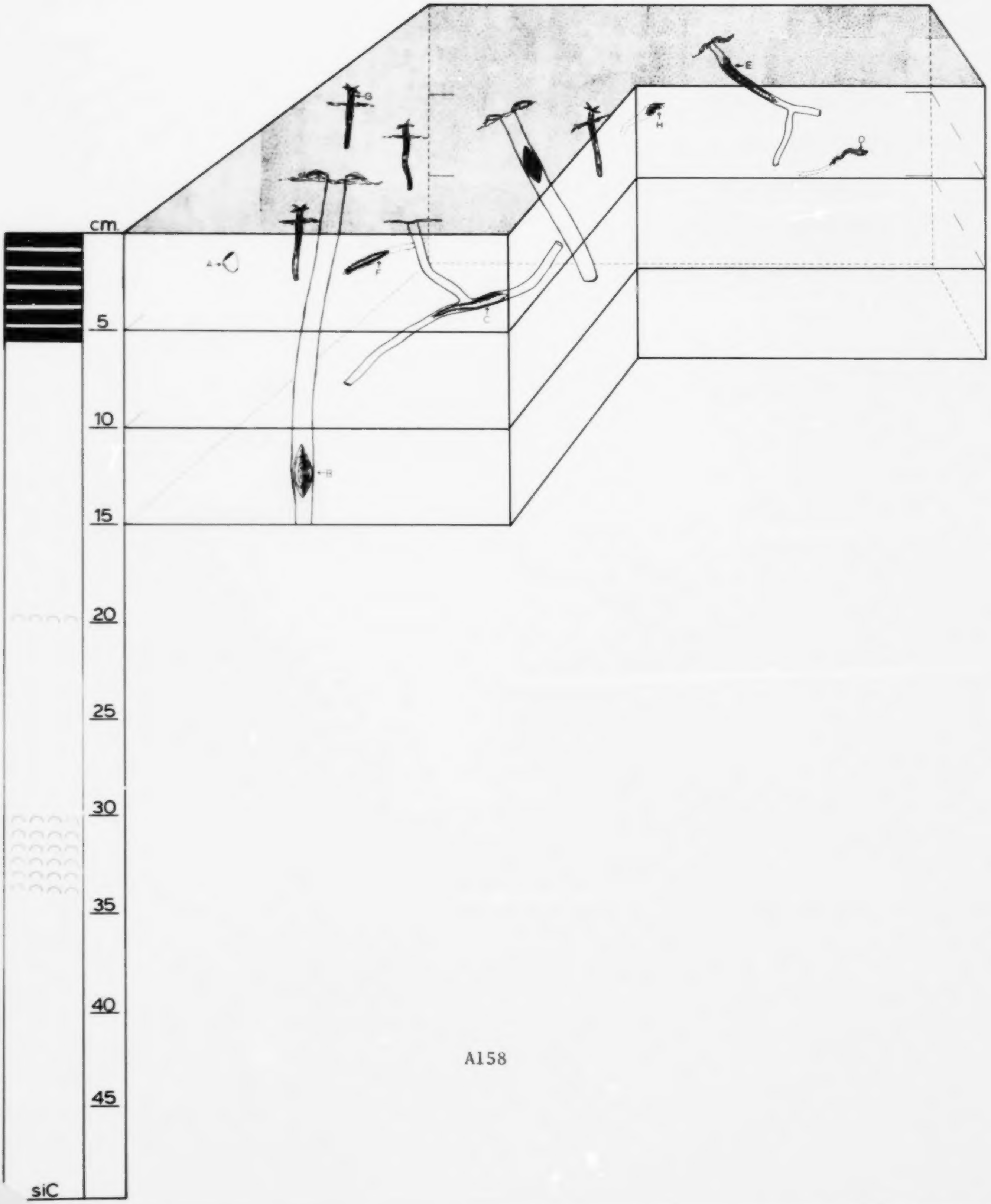
E. Nereis succinea

F. Eteone heteropoda

G. Streblospio benedicti

H. Leptocheirus plumulosus

MD. 57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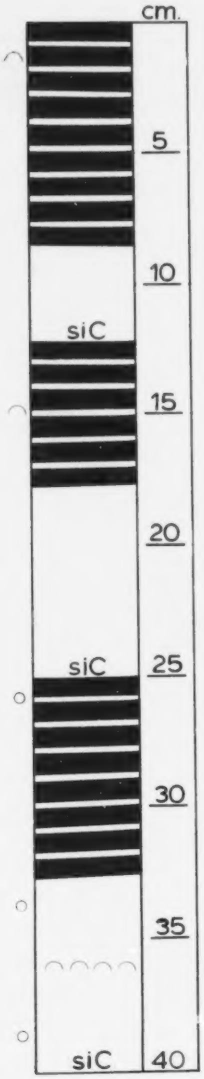
MD. 58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Station 59

(Summer 1979)

A. *Cerebratulus lacteus*

B. Nemertean sp.

C. *Retusa canaliculata*

D. *Lyonsia hyalina*

E. *Mulinia lateralis*

F. *Mya arenaria*

G. *Macoma balthica*

H. *Macoma mitchelli*

I. Oligochaete sp.

J. *Heteromastus filiformis*

K. *Glycera dibranchiata*

L. *Nereis succinea*

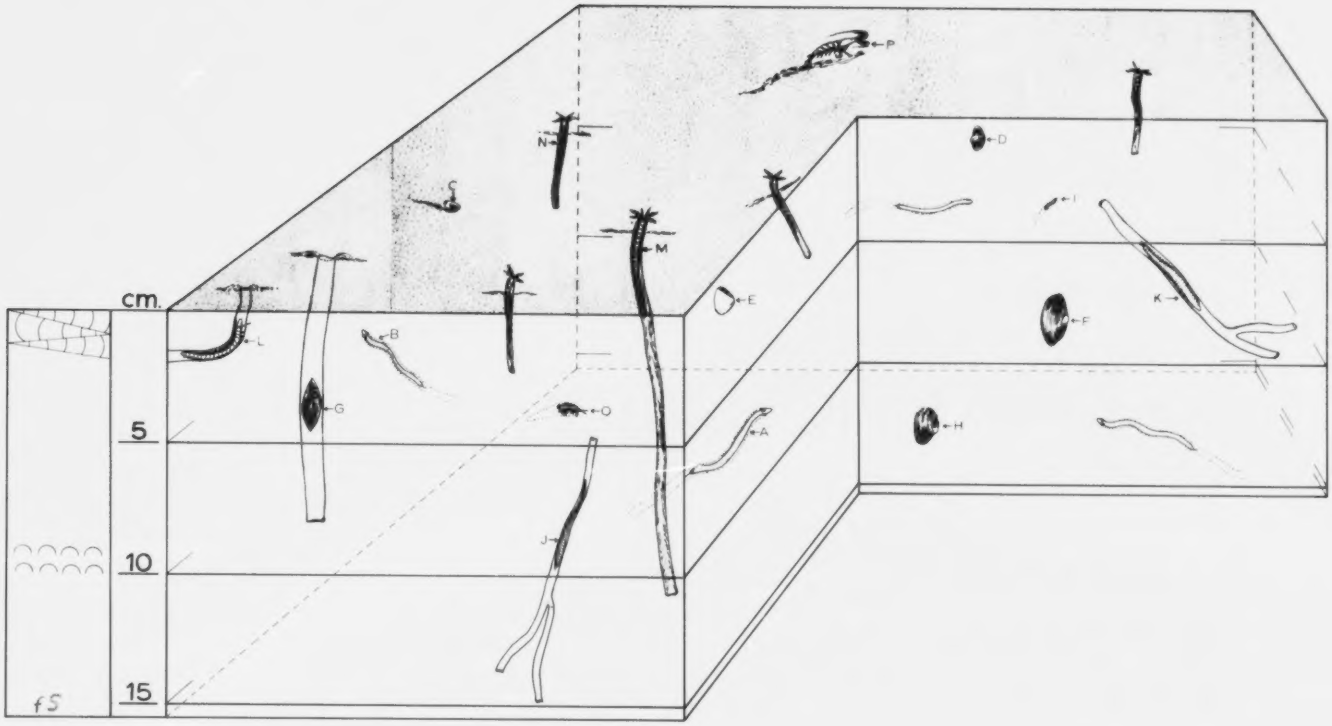
M. *Paraprionspio pinnata*

N. *Streblospio benedicti*

O. *Leptocheirus plumulosus*

P. *Neomysis americana*

MD. 59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Station 60

(Summer 1979)

A. Nemertean sp.

B. *Mulinia lateralis*

C. *Macoma balthica*

D. *Macoma mitchelli*

E. *Heteromastus filiformis*

F. *Nereis succinea*

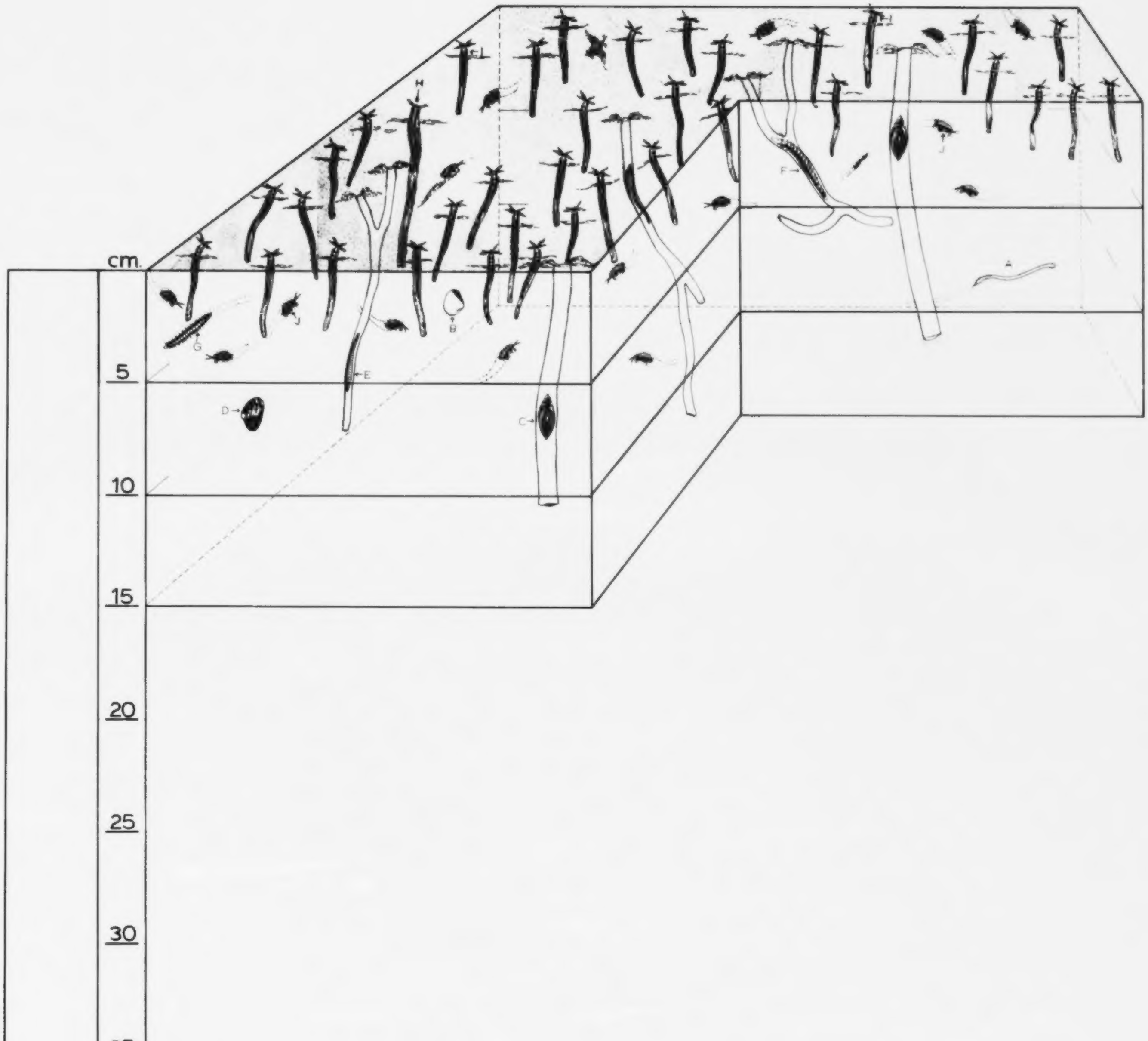
G. *Eteone heteropoda*

H. *Scolecolepides viridis*

I. *Streblospio benedicti*

J. *Leptocheirus plumulosus*

MD. 60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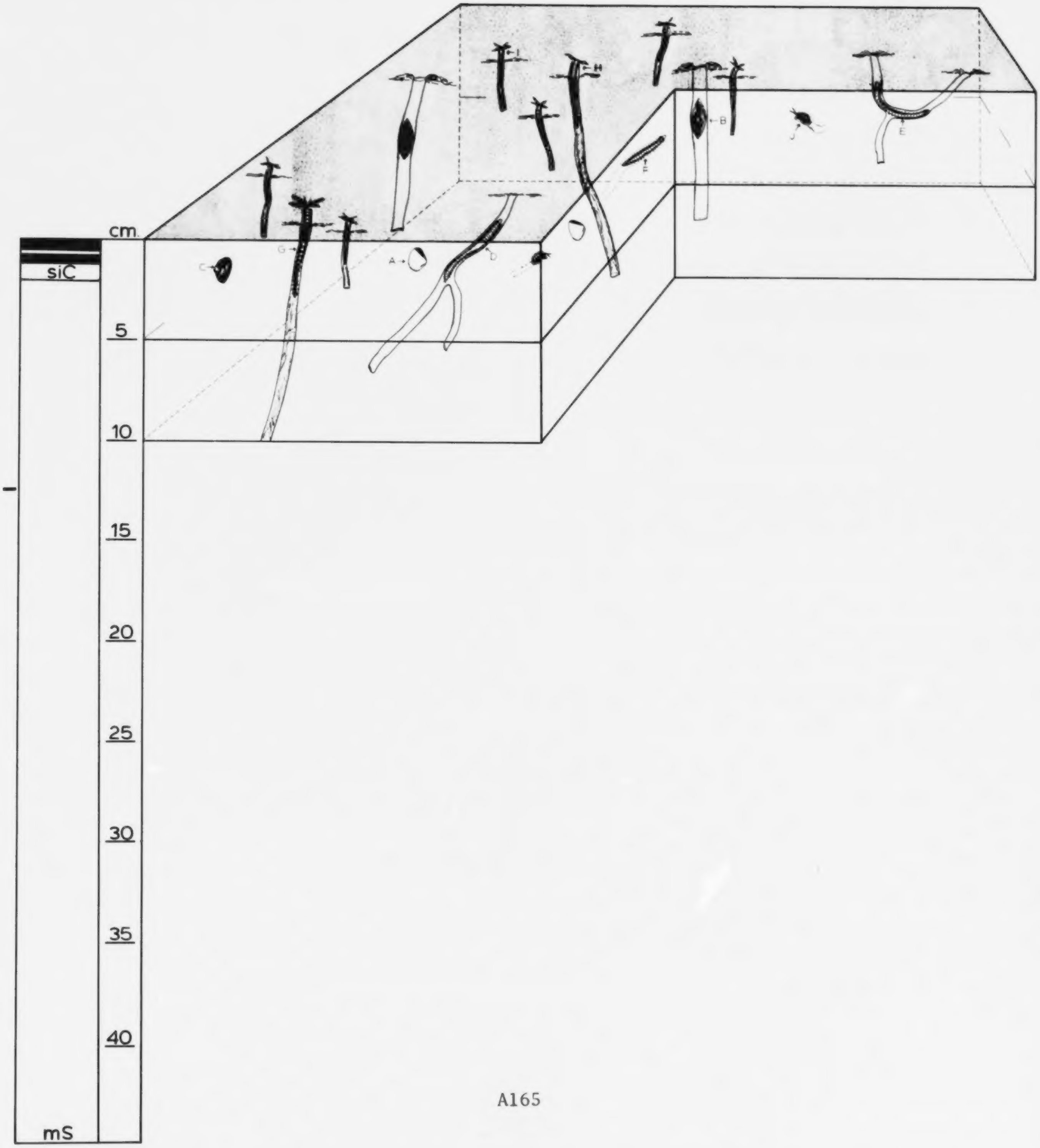
Station 61

(Summer 1979)

A. *Mulinia lateralis*
B. *Macoma balthica*
C. *Macoma mitchelli*
D. *Glycera dibranchiata*
E. *Nereis succinea*
F. *Eteone heteropoda*
G. *Paraprionspio pinnata*
H. *Scolecolepides viridis*
I. *Streblospio benedicti*
J. *Leptocheirus plumulosus*

MD. 61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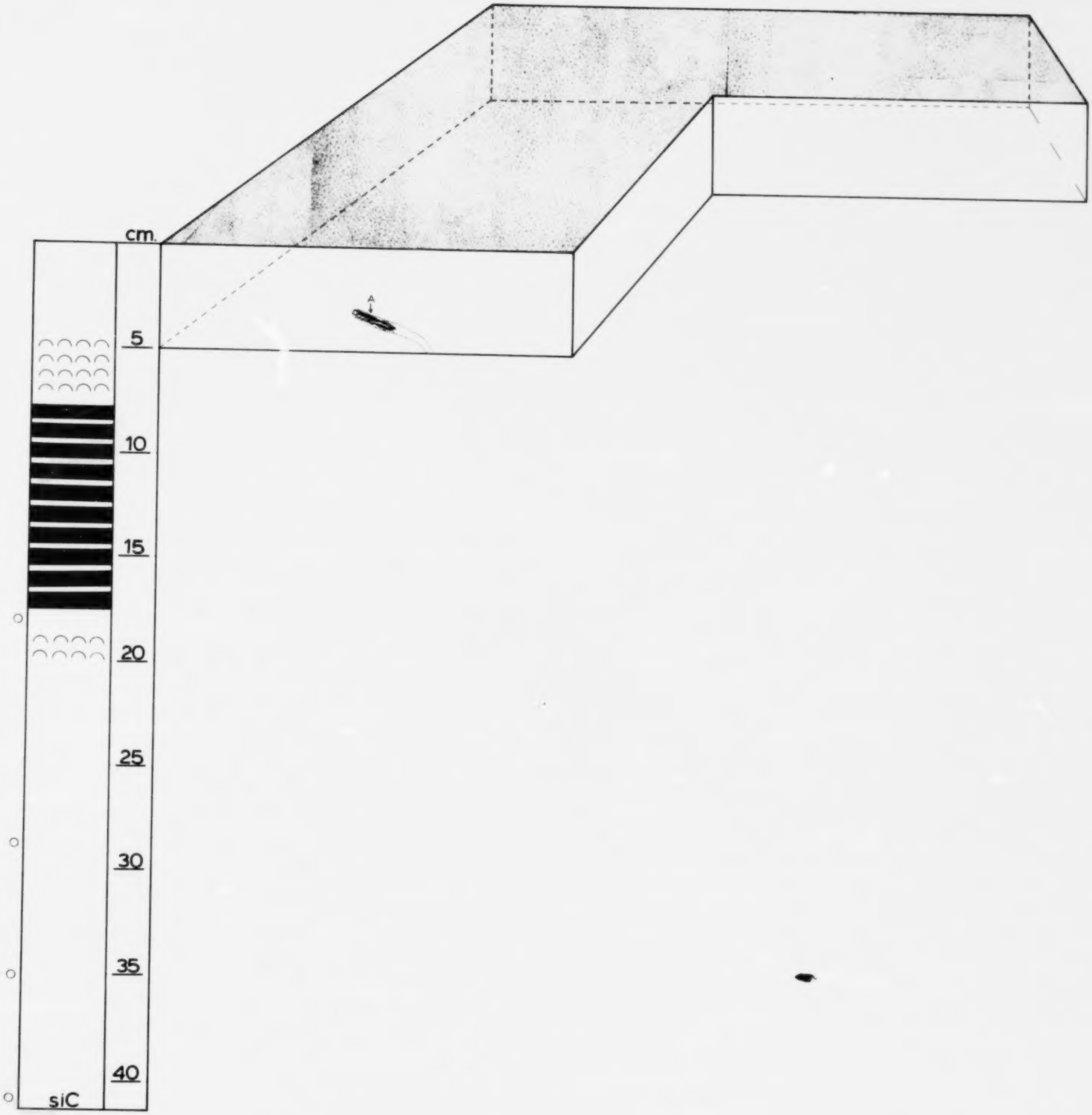
Station 62

(Summer 1979)

A. *Pseudeurythoe ambigua*

MD. 62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Station 63

(Summer 1979)

A. *Cerebratulus lacteus*

B. Nemertean sp.

C. *Mulinia lateralis*

D. *Macoma balthica*

E. *Macoma mitchelli*

F. *Heteromastus filiformis*

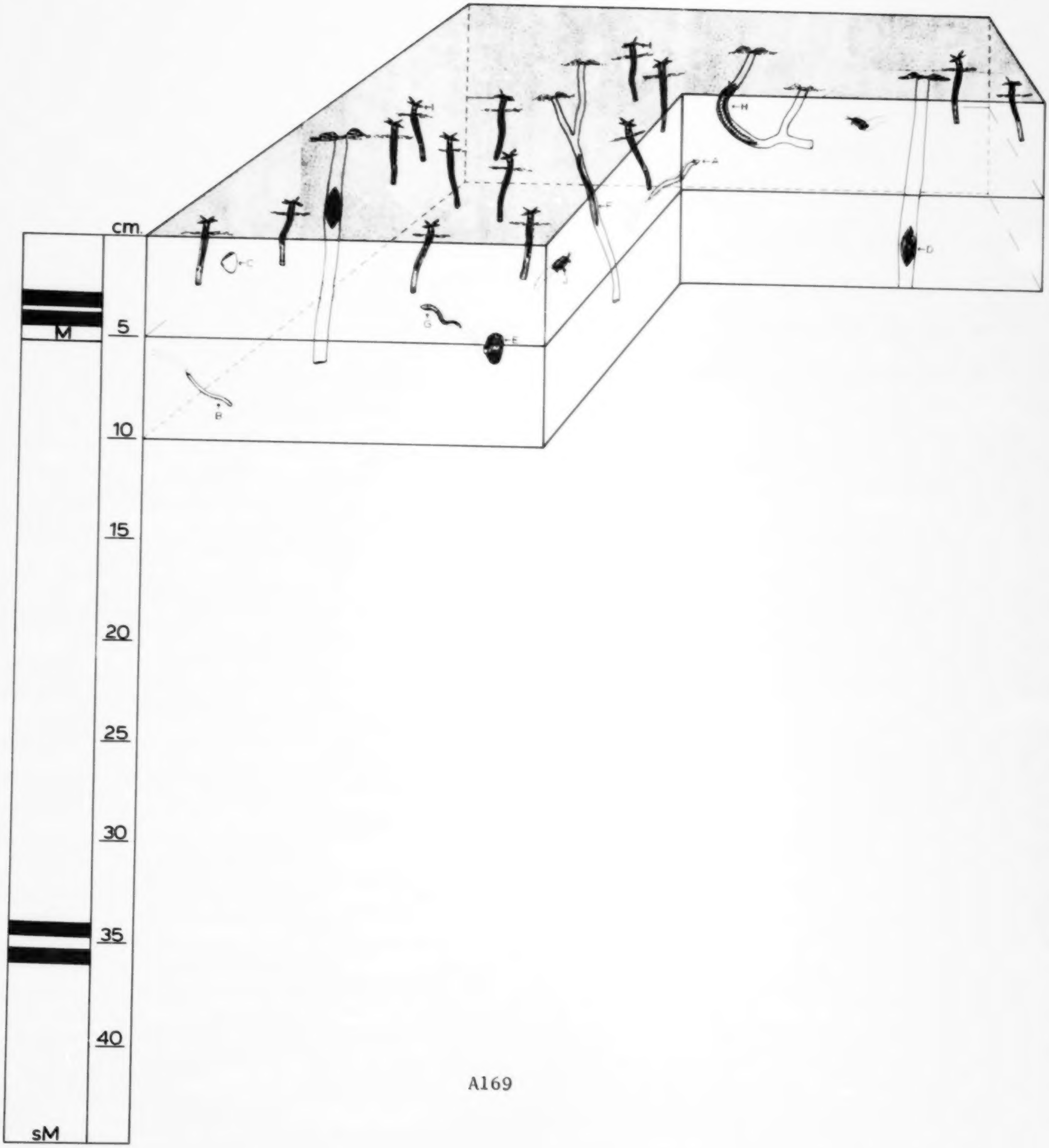
G. *Glycinde solitaria*

H. *Nereis succinea*

I. *Streblospio benedicti*

J. *Leptocheirus plumulosus*

MD. 63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Station 64

(Summer 1979)

A. Nemertean sp.

B. *Mulinia lateralis*

C. *Macoma balthica*

D. Oligochaete sp.

E. *Heteromastus filiformis*

F. *Nereis succinea*

G. *Paraprionspio pinnata*

H. *Scolecolepides viridis*

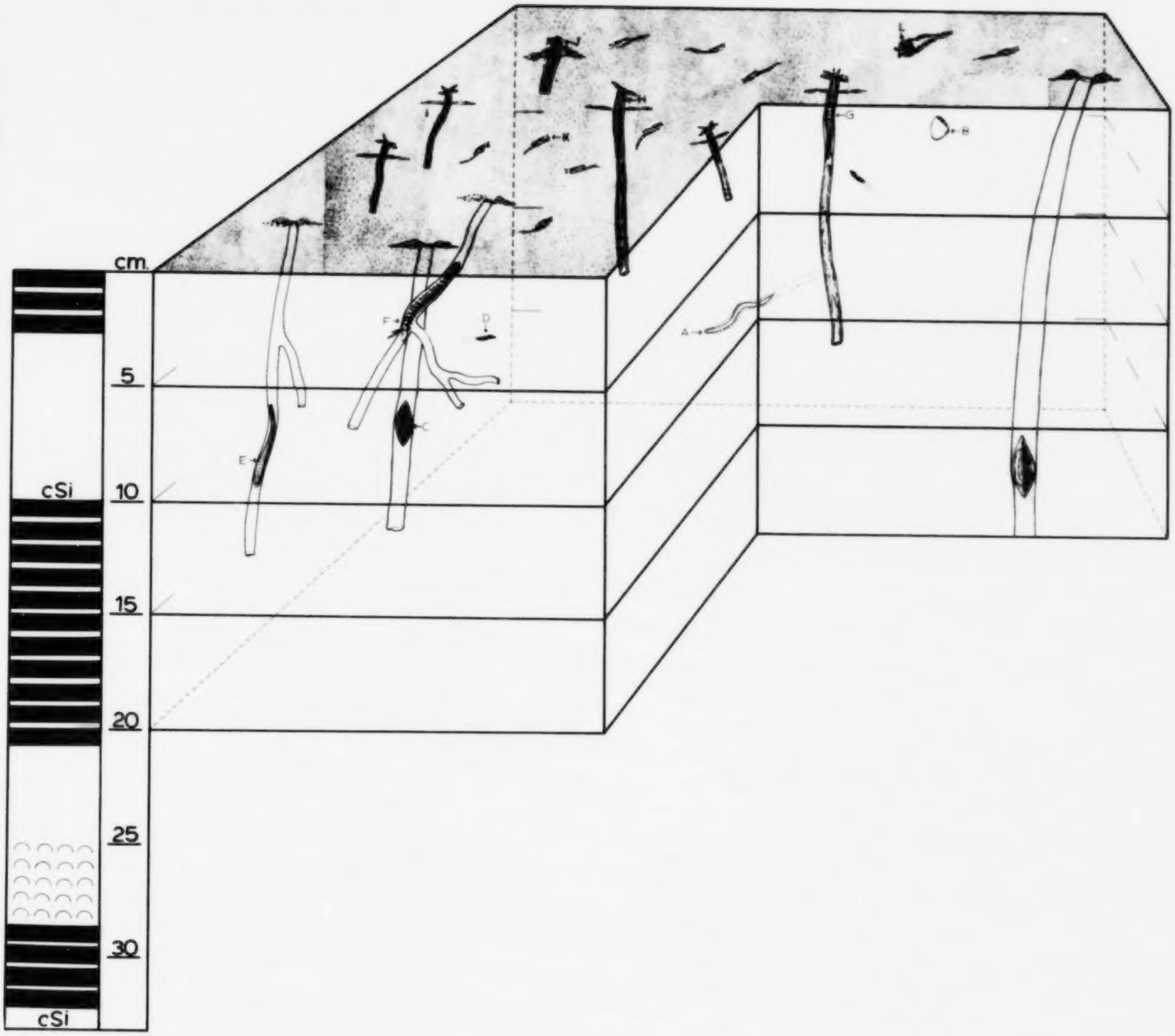
I. *Streblospio benedicti*

J. *Ampelisca abdita*

K. *Cyclaspis varians*

L. *Chirodotea caeca*

MD. 64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TYPING GUIDE SHEET

Station 65

(Summer 1979)

A. *Stylochus ellipticus*

B. Nemertean sp.

C. *Retusa canaliculata*

D. *Lyonsia hyalina*

E. *Mulinia lateralis*

F. *Mya arenaria*

G. *Macoma balthica*

H. *Macoma mitchelli*

I. *Pseudeurythoe ambigua*

J. *Amphicteus floridans*

K. *Heteromastus filiformis*

L. *Glycera dibranchiata*

M. *Nereis succinea*

N. *Pectinaria gouldii*

O. *Eteone heteropoda*

P. *Paraprionspio pinnata*

Q. *Polydora ligni*

R. *Streblospio benedicti*

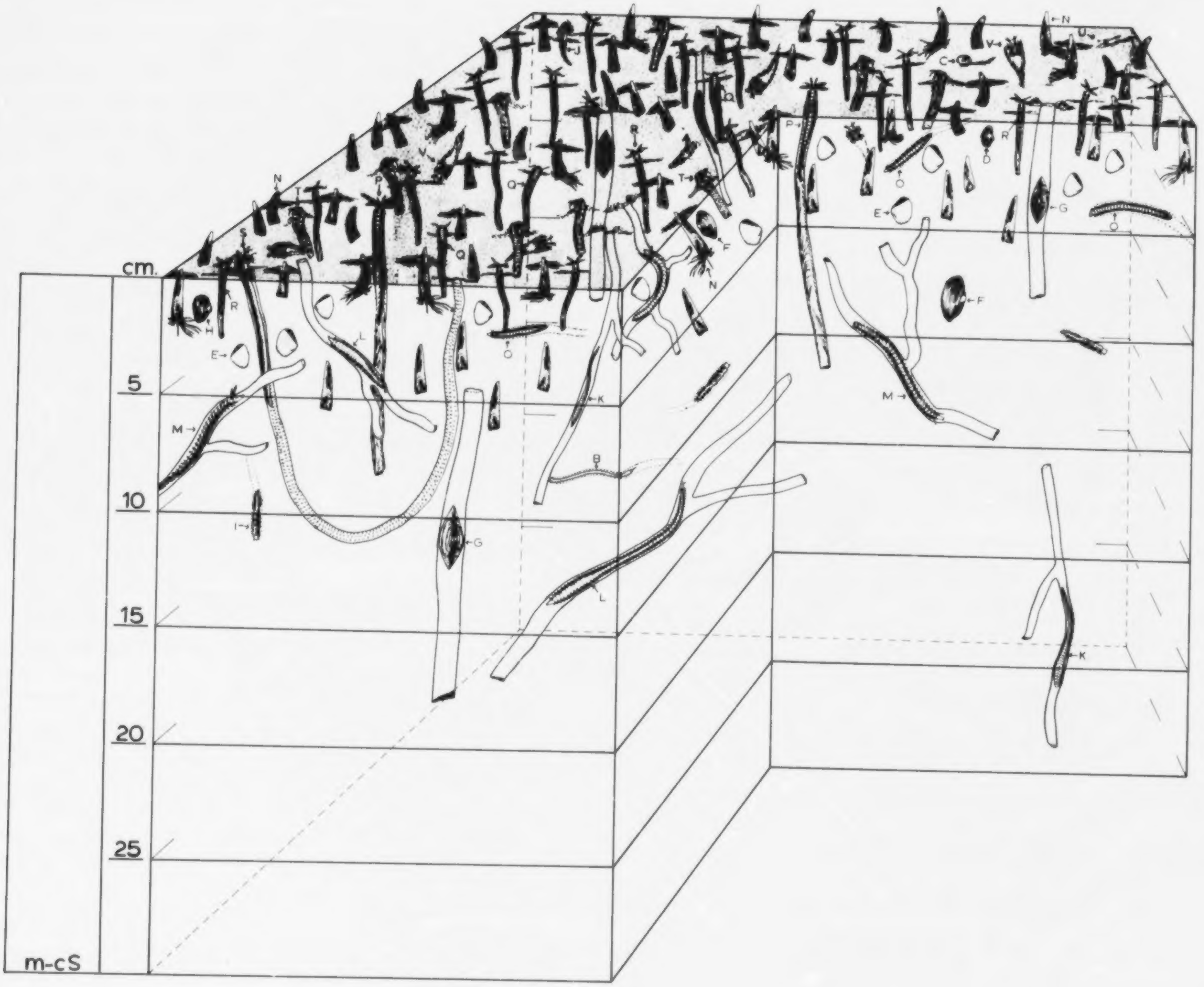
S. *Loimia medusa*

T. *Ampelisca abdita*

U. *Cyclaspis varians*

V. *Chriodotea caeca*

MD. 65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Appendix V. Radiographs of representative sedimentary environments in the upper and central Chesapeake Bay.

Plate 1. Station 1, Medium-coarse sand environment.

Station 1:	Mouth of the Susquehanna River
Latitude:	39 32 59.675
Longitude:	76 4 27.503

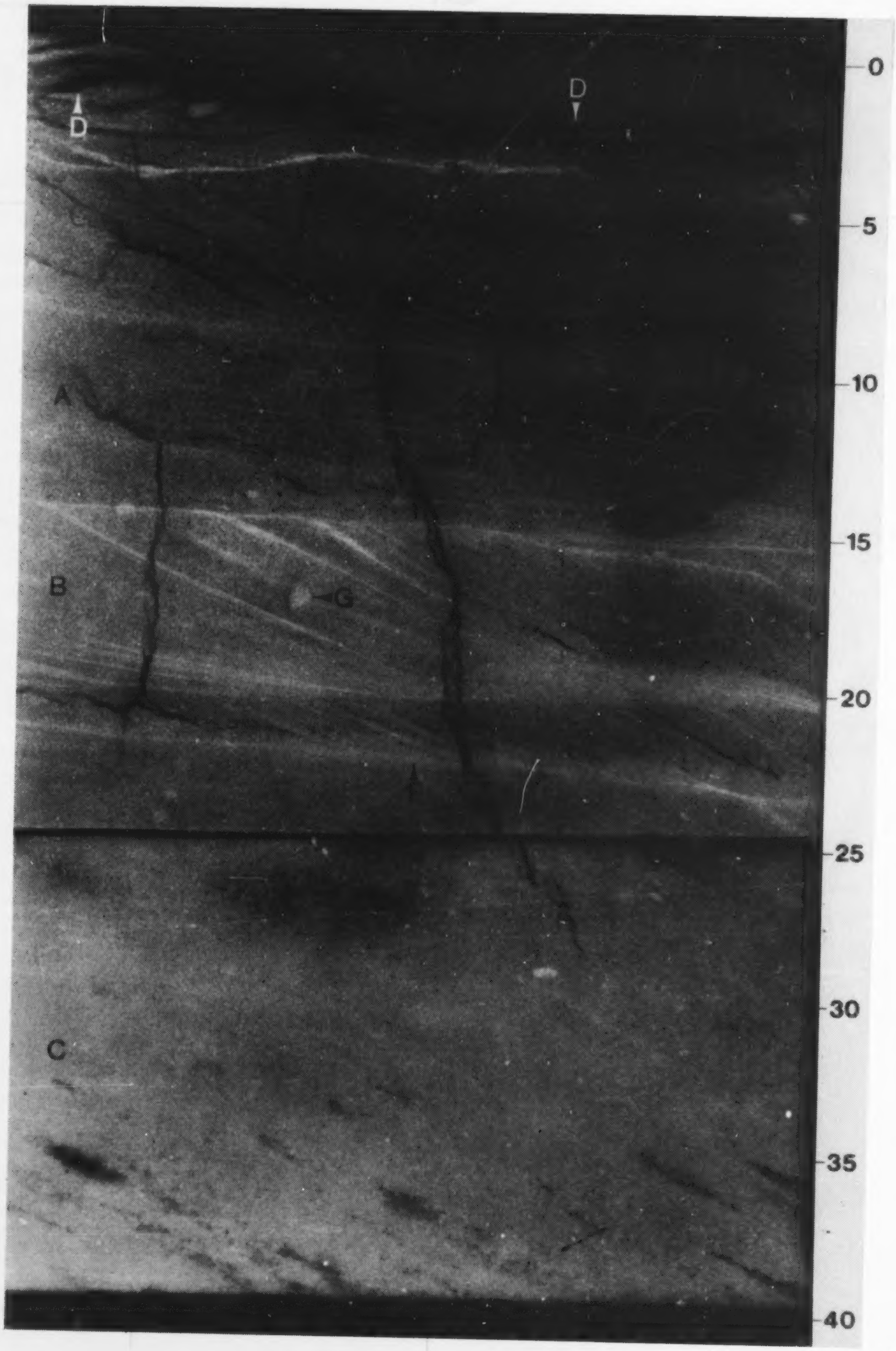
Sampling Date: 7/5/79
Water Depth: 10.38 m
Radiographic negative print

COARSE-MEDIUM SAND ENVIRONMENT:

The sand flats of the upper Chesapeake Bay illustrate characteristic physical features. Variable energy dynamics are indicated by large-scale crossbedding; these being enhanced by heavy minerals. Although mud accounts for a small percentage of this sediment texture, flaser structures are occasionally evident.
Degree of bioturbation: 0%

SPECIAL FEATURES:

A. Homogenous sand bed
B. Heavy mineral, trough-shaped cross-bedding unit
C. Planar cross-bedding, composed of coal fragments
D. Mud flasers
E. Heavy mineral ripple lamina
F. Heavy mineral laminae indicating different bedding units
G. Pebbles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EPA Form 2350-4 (4-80)

TYPING GUIDE SHEET

Plate 2. Station 12, Fine sand environment.

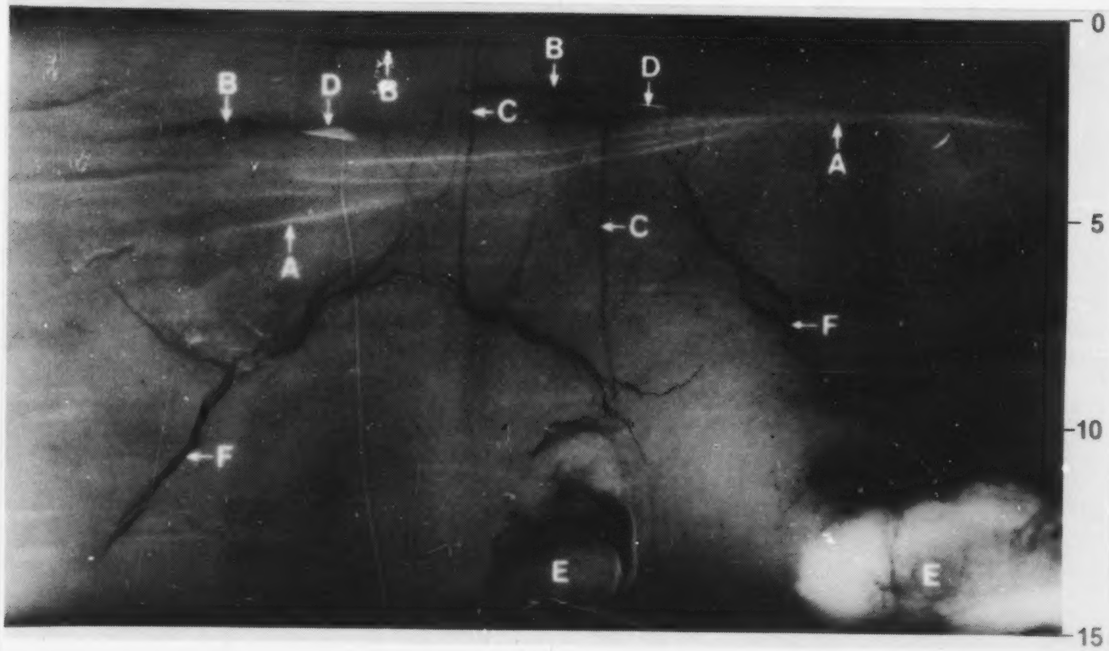
Station 12: Eastern shore of Eastern Bay
Latitude: 38°53' 6.5"
Longitude: 76°13'23.9"
Sampling Date: 10/2/78
Water Depth: 6.10 m
Radiographic positive print

Fine Sand Environment:

Small-scale cross-bedding is a characteristic sedimentary feature of mobile, fine sand environments. Ripple laminations are usually enhanced by heavy minerals. Less frequently, such layers are coated by silts and clays, thus producing mud flasers. The preservation of these sedimentary structures is rare in most other fine sand regimes.
Degree of Bioturbation: <30%

Special Features:

A. Small-scale, trough-shaped ripple laminae outlined by heavy minerals (light grains)
B. Mud flasers
C. *Paraprionspio pinnata* tube traces (active)
D. Assorted shell fragments
E. *Crassostrea virginica* shell fragments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EPA Form 2358-4 (4-80)
(PREVIOUSLY OID EPA FORM 241)
TYPING GUIDE SHEET

Plate 3. Station 2, Mixed-sediment environment.

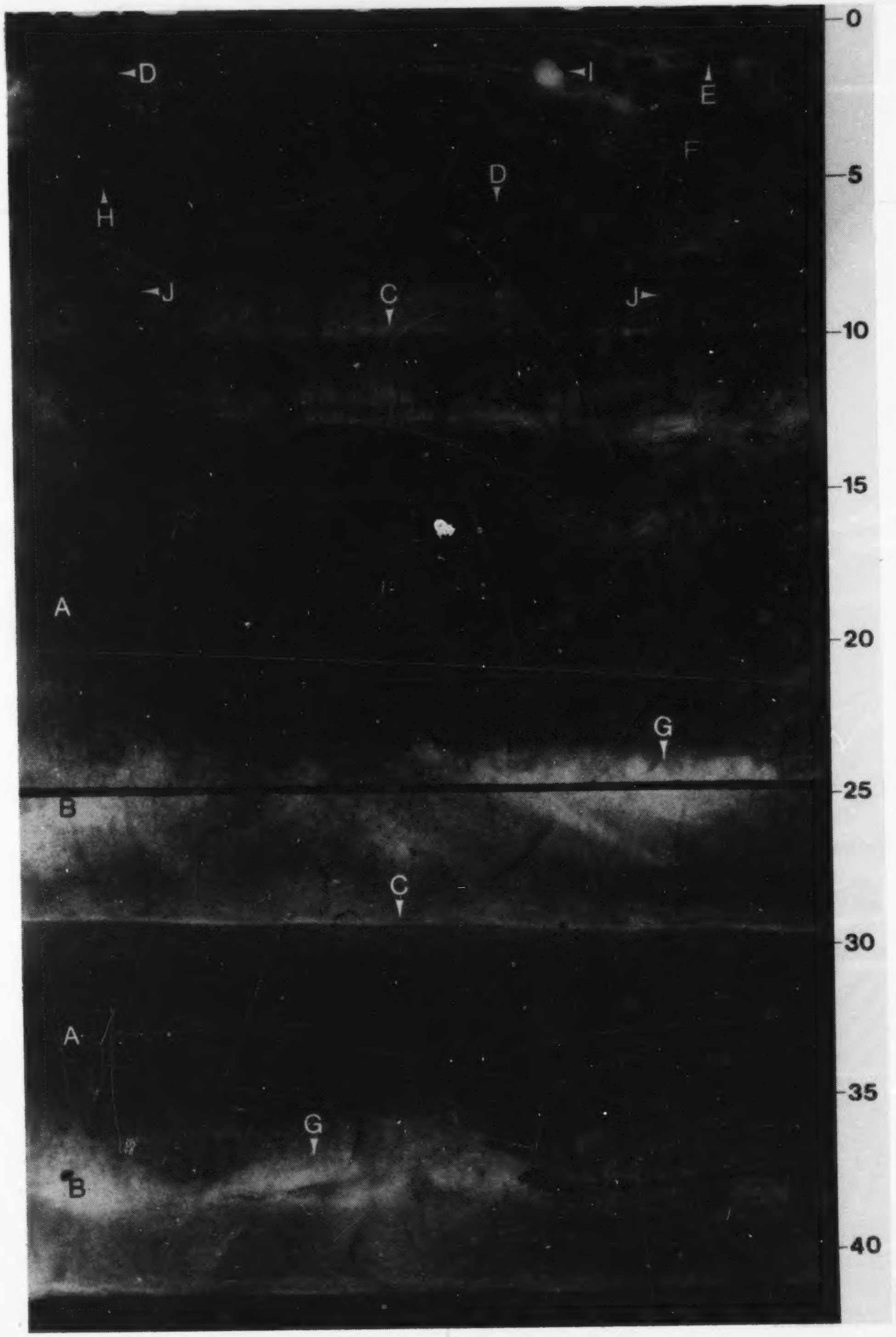
Station 2: Neck of Susquehanna sand flats
Latitude: 39 24 50.510
Longitude: 76 2 31.456
Sampling Date: 9/28/78
Water Depth: 6.71 m
Radiographic negative print

MIXED-SEDIMENT ENVIRONMENT:

Interbedded mud and sand is a common sedimentary feature in the mixed-sediment environments. The physically disrupted, alternating units in this print are due to the movement of the maximum turbidity zone and variable current dynamics inherrent to the upper Bay. The wider sand laminae have broken up into sand lenses. *Scolecolepides viridis* produces individual mucus tubes.
Degree of bioturbation: <30%

SPECIAL FEATURES:

A. Thick mud laminae
B. Disrupted sand laminae
C. Thin sand laminae
D. Wavy ripple lamination
E. Mud flaser
F. Mud pocket
G. Sand lenses
H. Twig
I. Pebble
J. *Scolecolepides viridis* tube traces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EPA Form 2350-4 (4-00)

TYPING GUIDE SHEET

Plate 4. Station 55, Mud environment.

Station 55: Channel station near Bloody Point area
Latitude: 38 48 50.359
Longitude: 76 23 38.165
Sampling Date: 7/3/79
Water Depth: 31.45 m
Radiographic negative print

MUD ENVIRONMENT:

This radiograph shows coastal plain deposits with mud laminae overlying sand layers. Randomly oriented pockets are methane bubbles. Successful colonization by the opportunistic species, *Mulinia lateralis*,has been thwarted due to high sedimentation rates (≈17.8 mm/yr) and anoxic conditions. Tubes of former dense populations of *Pecintaria gouldii* are left intact.
Degree of bioturbation: trace (top half)
<30% (bottom half)

SPECIAL FEATURES:

A. Thin mud (silty clay) laminae
B. Homogenous mud layer
C. Fine sand lamina
D. Clay zone
E. Sand lenses
F. Methane bubbles
G. *Mulinia lateralis* shell laminae
H. Fine sand lamina composed of *Pectinaria gouldii* tube remnants
I. Unidentified polychaete burrows

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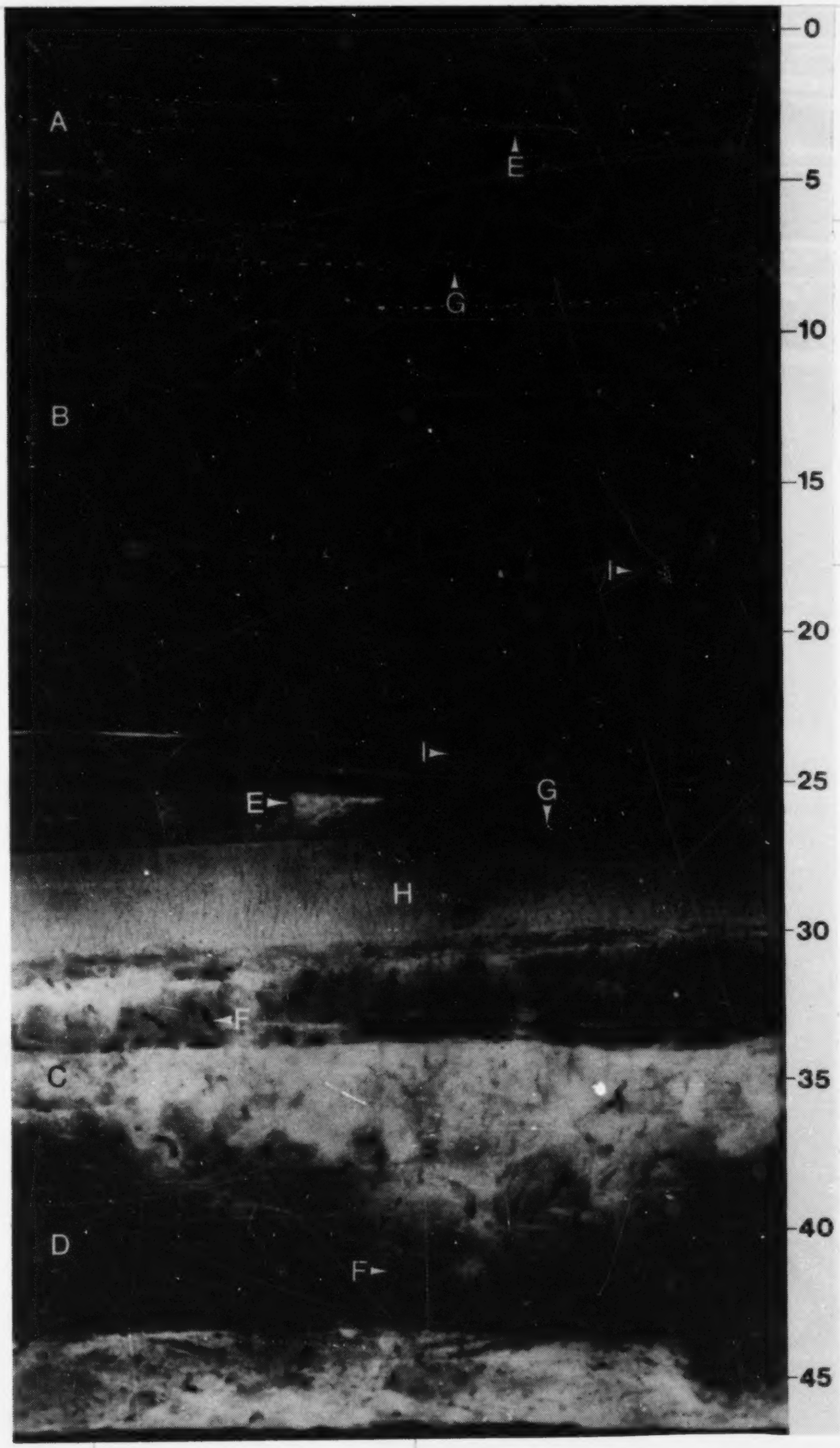
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Plate 5. Station 63, Mixed-sediment environment.

Station 63: Eastern Shore just south of Lower Hooper Island
Latitude: 38 11 39.616
Longitude: 76 8 13.826
Sampling Date: 6/28/79
Water Depth: 7.55 m
Radiographic negative print

MIXED-SEDIMENT ENVIRONMENT:

The bioturbated sandy mud core manifested here shows a faint interbedded mud-sand layer which is indicative of the prior, physical structured environment. Several biogenic traces are evident, those of *Glycera dibranchiata* being the most pervasive. This polychaete is responsible for sediment disruption.
Degree of bioturbation: 90-99%

SPECIAL FEATURES:

A. Mud lamina
B. Interbedded mud-sand layer
C. *Streblospio benedicti* tube trace
D. *Glycera dibranchiata* burrows
E. Iron oxide halo surrounding the burrow of *Glycera dibranchiata*
F. *Macoma balthica* burrow (inactive)
G. Unidentified polychaete trace
H. *Mulinia lateralis* shell (disarticulated)

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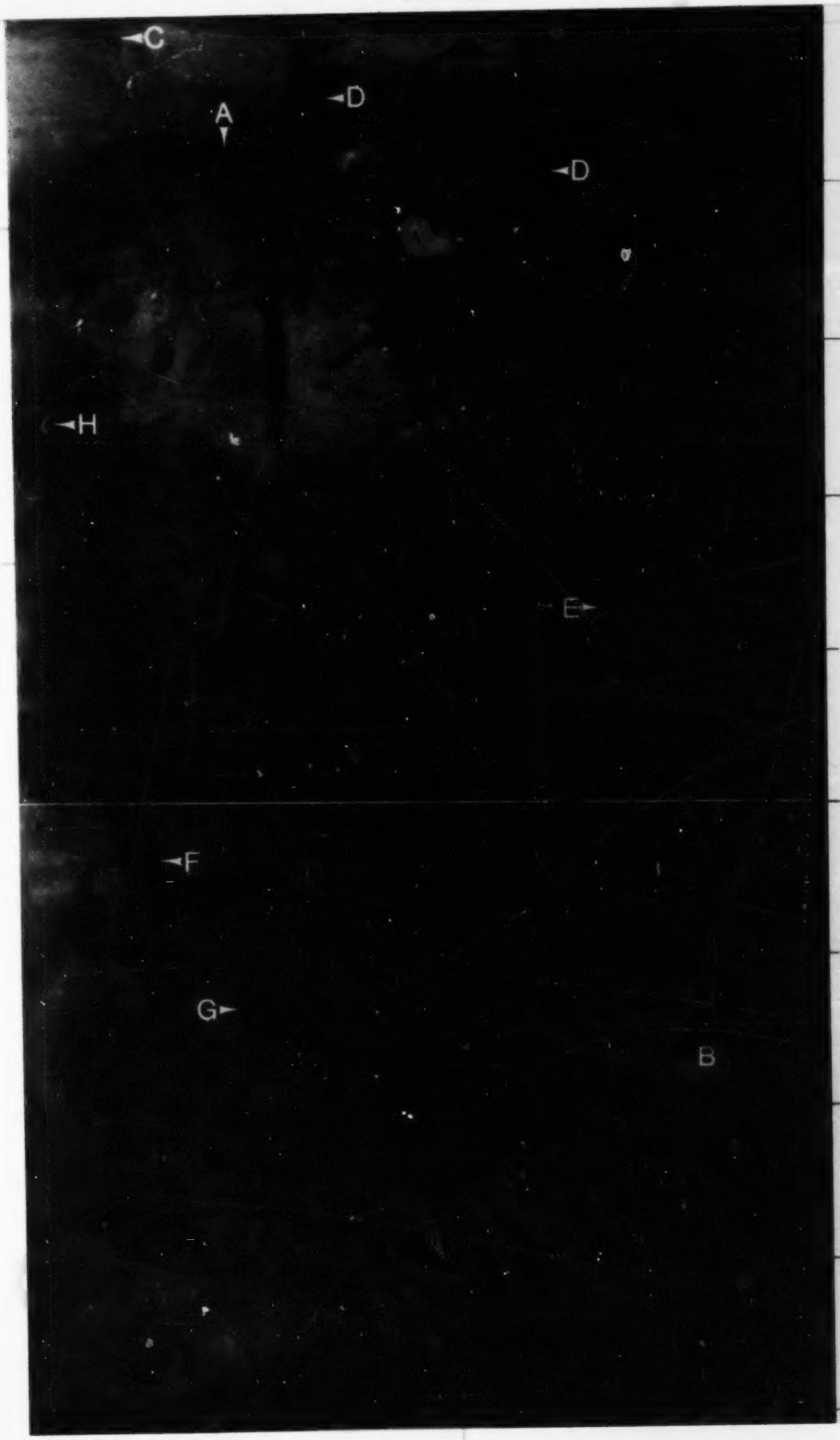

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Plate 6. Station 25, Fine sand environment.

Station 25: Eastern Shore just east of Smith Island
Latitude: 37 59 26.964
Longitude: 76 7 34.464
Sampling Date: 11/3/78
Water Depth: 9.15 m
Radiographic negative print

FINE SAND ENVIRONMENT:

Bioturbation activities have destroyed physical structures in this environment. Only well-maintained biogenic features remain. Scour marks surround the tubes of *Phoronis* sp. which may indicate destabilization at the sediment surface.
Degree of bioturbation: 90-99%

SPECIAL FEATURES:

A. Scour marks
B. *Phoronis* sp. tubes
C. *Glycera dibranchiata* burrow
D. Unidentified polychaete burrow
E. *Ilyanassa vibex* shell (remnant)

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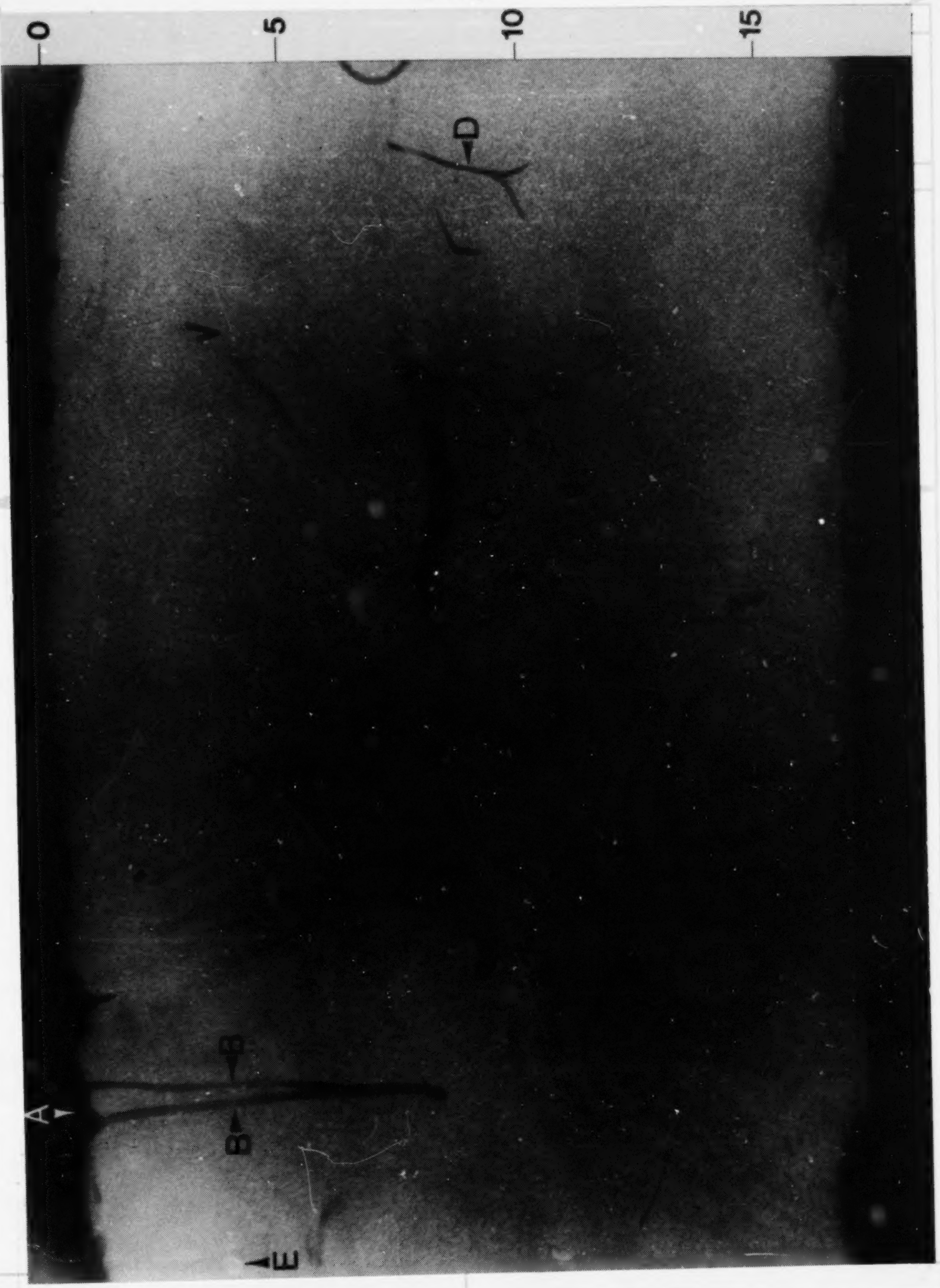

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Plate 7. Station 52, Mixed-sediment environment.

Station 52: Confluence of Elk and Bohemia rivers
Latitude: 39 28 50.316
Longitude: 75 56 20.907
Sampling Date: 7/4/79
Water Depth: 4.40 m
Radiographic negative print

MIXED-SEDIMENT ENVIRONMENT:

Propeller-generated turbulence is the probable cause of the massive disturbance depicted in this core. The thin mud-sand laminae are produced by tidal fluctuations. The ripple laminae and interbedded mud and sand layers below this zone are also characteristic of this environment. The surface shell layer was probably the result of the mass mortality of *Rangia cuneata* during the winter storm of 1977. The sedimentation rate in this area is ≈2 mm/yr.
Degree of bioturbation: <30%

SPECIAL FEATURES:

A. Silty sand texture
B. Clayey silt texture
C. Thin, parallel interlayered clay, silt and sand
D. Interbedded mud and sand and wavy ripple lamination
E. Mud flaser
F. Mud lamina
G. *Rangia cuneata* shells (disarticulated)
H. *Scolecolepides viridis* tube traces (active)
I. *Scolecolepides viridis* tube traces (inactive)
J. Fishing line

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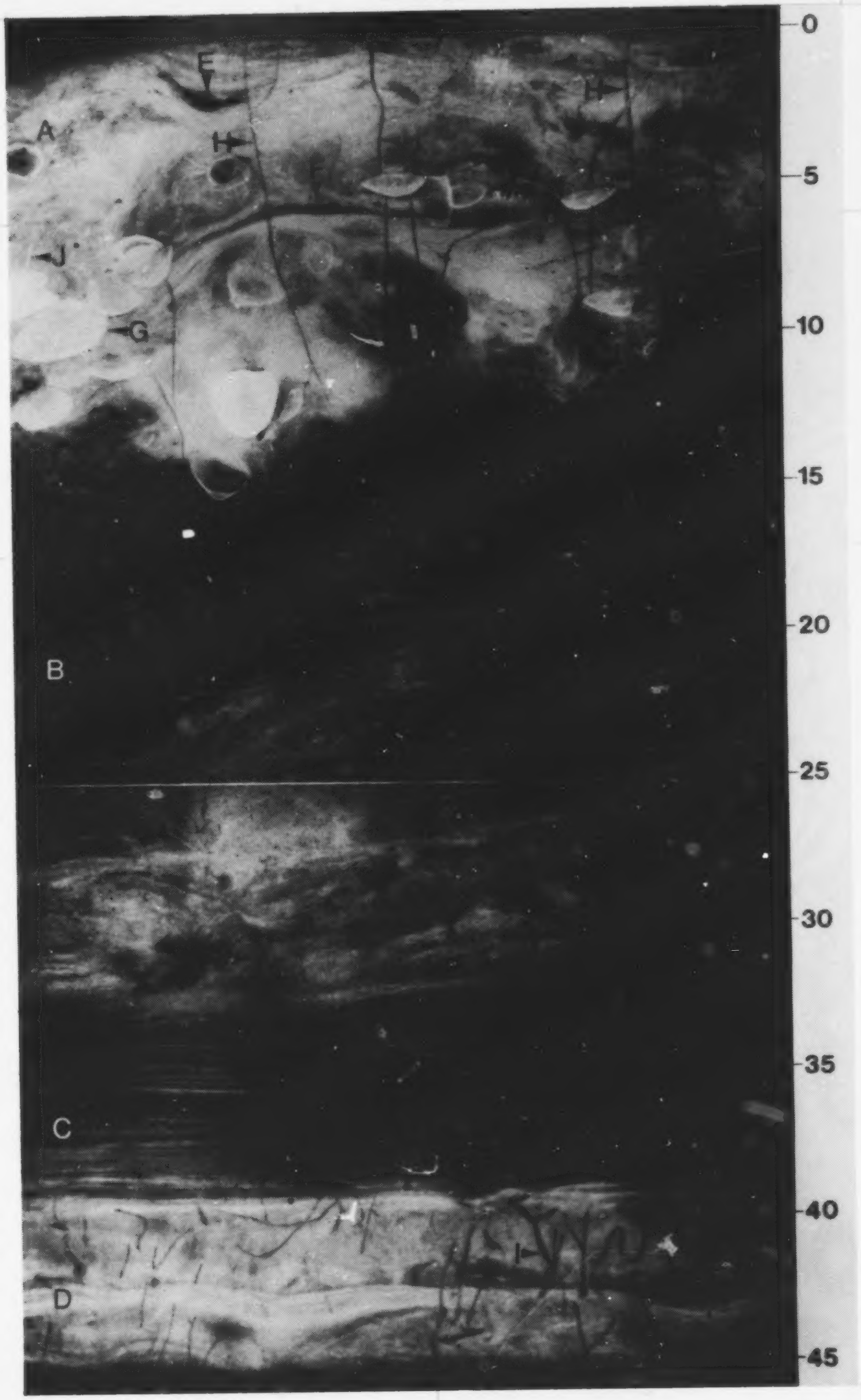
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Plate 8. Station 7, Mixed-sediment environment.

Station 7: Belvedere Shoals
Latitude: 39 7 16.261
Longitude: 76 21 52.765
Sampling Date: 7/3/79
Water Depth: 5.03 m
Radiographic negative print

MIXED-SEDIMENT ENVIRONMENT:

The mud-sand laminae depicted here are a result of dredging activities. Subsequent to dumping the biota repopulated and reworked the sediments. Shell concentrations reflect mass mortalities of benthic species and current transport.
Degree of bioturbation: 60-90% (top half)
0% (bottom half)

SPECIAL FEATURES:

A. Sandy mud texture
B. Clayey silt layer
C. Fine sand lamina
D. Compacted clay balls
E. Coarse-medium sand lamina
F. Heterogenous shell lamina
G. *Rangia cuneata* shells (boxed and disarticulated)
H. *Crassostrea virginica* shell (fragment)
I. Pebbles
J. *Cyathura polita* burrow
K. *Macoma balthica* burrow

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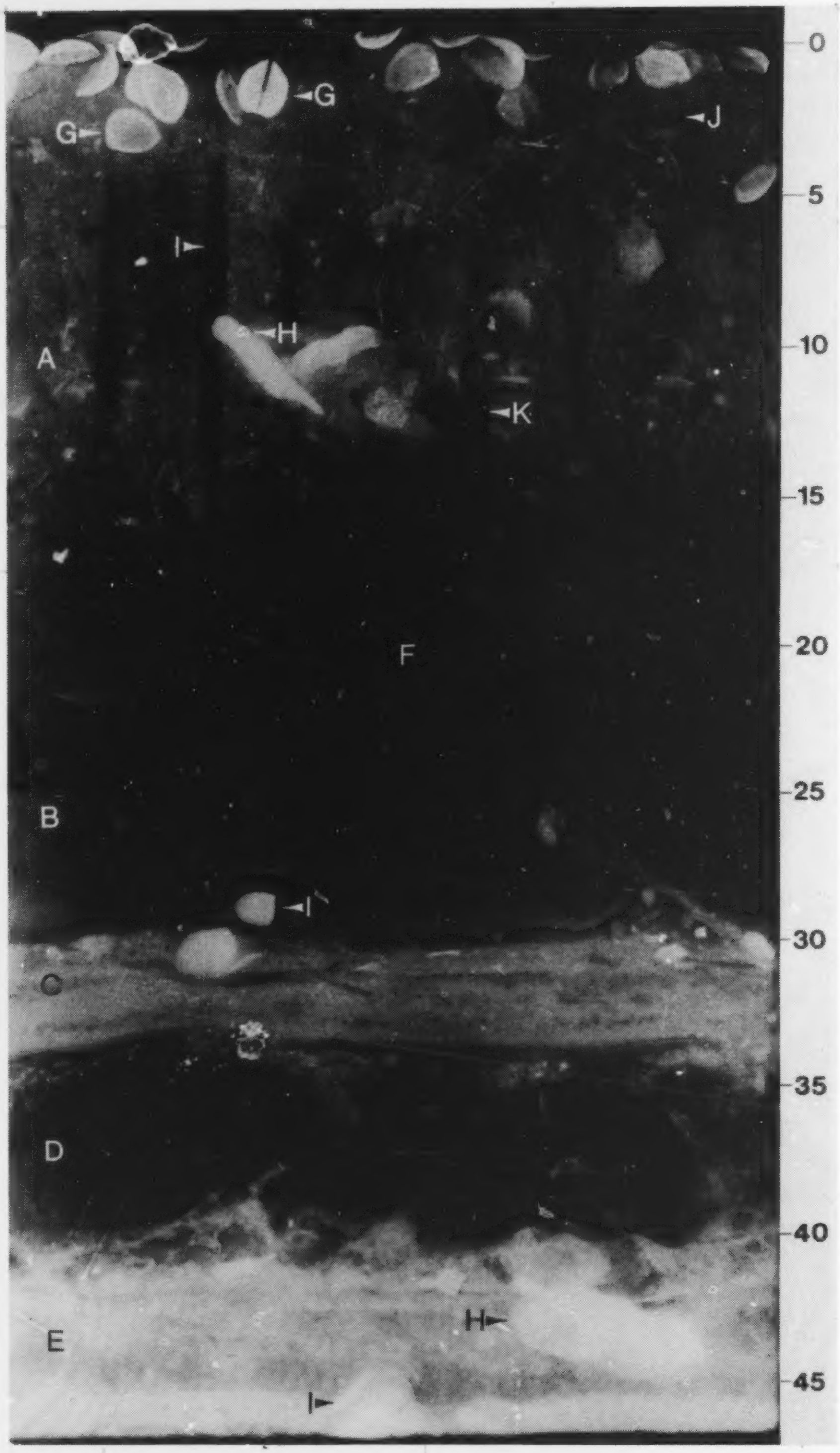
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